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Spatial econometric analysis of Louisiana rural real estate values

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SPATIAL ECONOMETRIC ANALYSIS OF LOUISIANA RURAL REAL ESTATE VALUES

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ABSTRACT

The general purpose of this study was to conduct a spatial analysis of the dynamics of rural land values in Louisiana. Specifically, spatial econometric procedures and hedonic price analysis were used to evaluate the impact of land characteristics on land prices across rural land markets in Louisiana.

Initially, hedonic models were estimated by ordinary least squares (OLS) procedures to test for the presence of spatial autocorrelation using Lagrange Multiplier tests. Results suggested that there was spatial autocorrelation in the error terms. Hedonic models were then estimated using maximum likelihood (ML) spatial error techniques. Log likelihood numbers and likelihood ratio tests where used to compare OLS and ML model estimation, and the ML was better for these data.

Information for this study includes sales that were collected for the time period January 1, 1993 through June 30, 1998, and data collected as a part of this study for the period July 1, 1998 through June 30, 2002. Data on 3,542 Louisiana rural land sales were collected during the two periods using mail survey techniques. Geo-reference of these sales indicated that sales were evenly dispersed throughout the state. Results from the data indicate that there is a substantial variation in rural real estate prices across the state.

Results from hedonic model estimation showed that cropland, pastureland, government program cotton base acreage, month of sale, value of improvements, paved road access, reasons for purchase residential, commercial and investment; residential, commercial, and highway influences; statistical metropolitan areas, and inverse of travel time had statistically significant positive influences on per acre land values. Meanwhile, size of tract, distance to nearest town, travel time to nearest town, flood influence, and reasons for

purchase farm expansion and recreational had a statistically significant inverse relationship with per acre rural land values.

Marginal implicit prices were estimated using the results from models estimated by OLS and ML spatial procedures. Results indicated that, in several instances, marginal implicit prices were overestimated or underestimated when using results from OLS estimation. In general, spatial econometric techniques can be used to improve the accuracy of rural land value estimates.

CHAPTER 1 . INTRODUCTION

Rural land markets are affected by several factors including agricultural economic conditions, population growth, land tract physical characteristics, location factors and other economic activity. Trends in United States and Louisiana agricultural real estate values have been characterized by a substantial increase, a subsequent decrease, and a relatively flat tendency over the last three decades (ERS). During the 1970's, prices of U.S. agricultural land increased and continued to increase until 1982, when agriculture real estate values decreased (Figure 1.1). Decreasing agricultural land value was coupled with a decline in the agricultural economy that began in the mid-1970's. In 1983, continuous increases in land values came to a quick end, falling 27 percent in five years (Knutson et al.).

In general, U.S. farm real estate values have been progressively increasing since 1987. Average agricultural land values have increased 102 percent, from $599 per acre in 1987 to $1,210 based on January 2002 values. It was not until January 1995, that the nominal average value of U.S. farm real estate exceeded the previous high in 1982 ($832 per acre). The most recent survey indicates that U.S. average nominal land values have continued to increase through 2002 (ERS). U.S. agricultural real estate values rose 4.6 percent during 2000 and seven percent during 2001 (Figure 1.2). The seven percent nominal increase in the national average value of agricultural real estate during 2001 marked the fifteenth consecutive yearly increase since 1987.

When nominal numbers are adjusted for inflation (1996=100), the U.S average farm land value in 2002 is lower than the record price reported in 1982 (Figure 1.1). U.S. real farm values continued to decline between 1982 until 1995 when real land values started to increase. The January 2002 average, on a real (or inflation-adjusted) basis, is still 12.2 percent below the 1982 average.

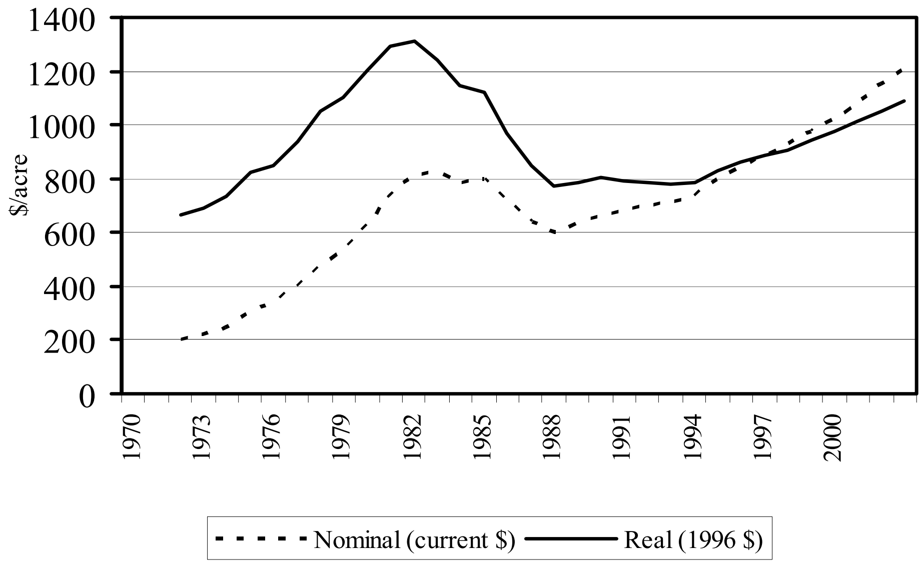

Figure 1.1. Annual average nominal and real values of U.S. farm real estate, 1970-2002.

In Louisiana, agricultural nominal real estate values increased from 1970 to 1982 (Figure 1.3). Then, nominal land values declined until 1987. After 1987, nominal farm prices have steadily increased. However, rural land values have not yet exceeded the record per acre value reported in 1981, as the January 2002 average remains 5.8 percent below the 1981 average (Figure 1.4). The largest annual percentage increase in Louisiana rural land values was nine percent between the years 1995 and 1996. The 2001-2002 data indicate that Louisiana agricultural nominal land values increased by five percent from the previous year.

It is important to mention the effects of inflation on the price of Louisiana agricultural land. The highest real farm land price ($/acre) in Louisiana was recorded in 1981. Real rural land values then decreased until 1992, with the exception of a higher real annual average price in 1986. Since 1993, real land prices have increased. The 2001-2002 records indicate that Louisiana real agricultural land prices have increased 3.7 percent over the year (Figure 1.4).

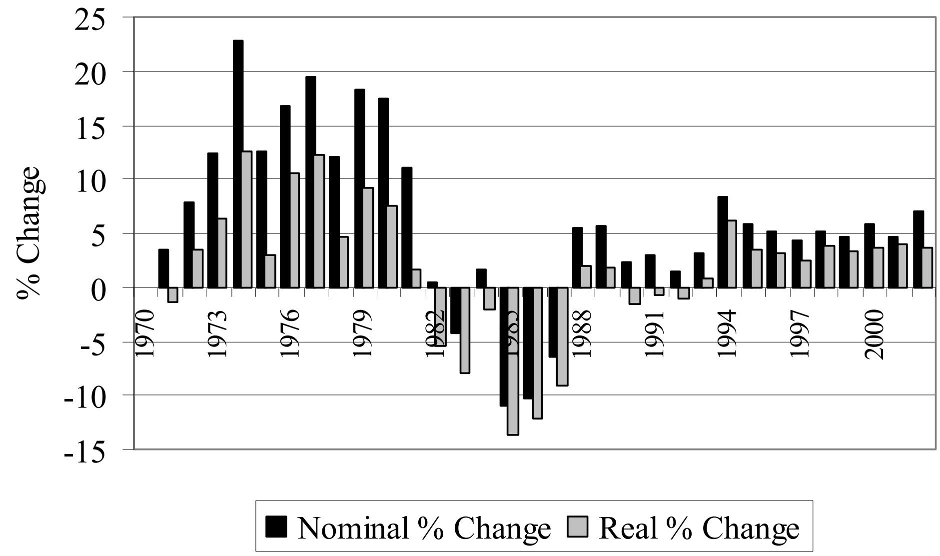

Figure 1.2. Annual average nominal and real percent change in U.S. farm real estate values, 1970-2002.

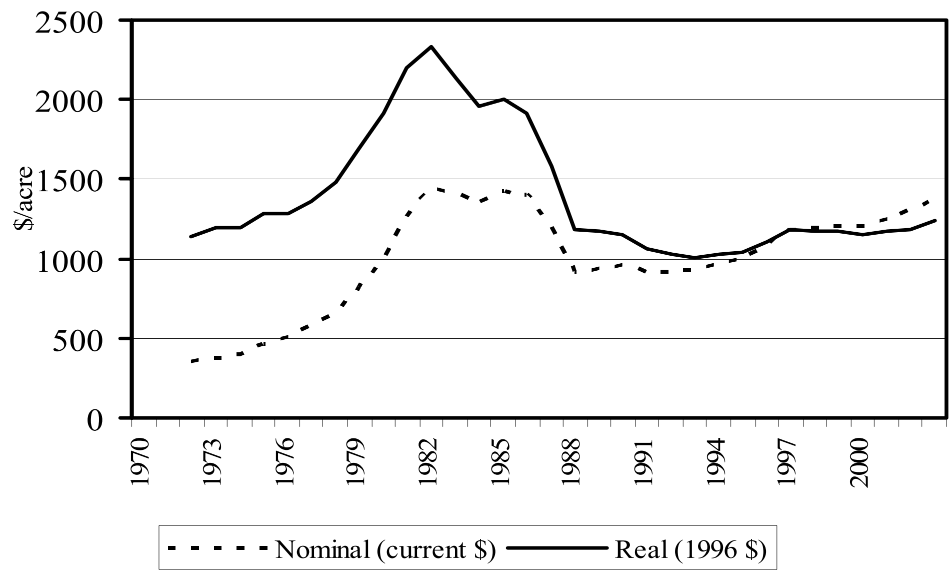

Figure 1.3. Annual average nominal and real values of Louisiana farm real estate, 1970-2002.

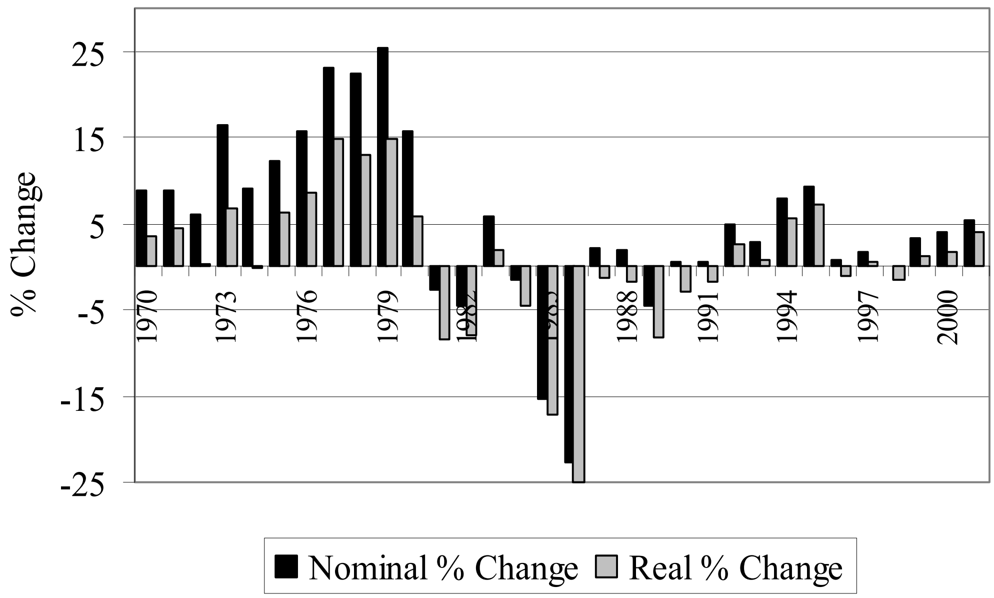

Figure 1.4. Annual average nominal and real percentage changes in Louisiana farm real estate values, 1970-2002.

The impact of fluctuations in rural land values is reflected within the balance sheet and capital structure of the agricultural sector. According to 1970 ERS data, Louisiana farm assets totaled about $4,849 million, of which $3,739 million (77 percent) were real estate. In 2000, assets in the Louisiana agricultural sector totaled $11,826 million, of which approximately 75 percent ($9,032 million) were real estate.

The U.S. Department of Agriculture annually estimates average rural land values. However, these estimates are highly aggregated. Previous rural land market research has focused on measuring factors that influence agricultural land values. An attempt to estimate rural land values in Louisiana was made by Kennedy (1995). However, this study did not account for, or correct, for spatial autocorrelation[1] in the data.

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[1] Relationship among values of a single variable that is attributable to the geographic arrangement of the variable's observation on a map (Griffith 1992).

Problem Statement

There is a need to update rural real estate market information in Louisiana. Unfortunately, annual information on Louisiana rural land values is very limited. One option is to obtain data from the United States Department of Agriculture (USDA) that reports annual estimates of average farm real estate values. Another source of data comes from the Census of Agriculture that is published every five years. Both of these sources contain limited information about the value of rural land in Louisiana because they do not take into account timberland, transitional land, and other factors that affect rural land values.

The Department of Agricultural Economics and Agribusiness at Louisiana State University collected detailed rural land market data from 1993 to 1998. This data base needed to be updated in order to identify market relationships and their implications in rural land markets. Data collection is the first step to building a data base for the rural land market. However, analysis of these data is also an important issue. It is obvious that the price of a tract of land depends on its location. However, for the Louisiana rural land market, improved estimation procedures that are needed to provide better measures of the effects of location on pricing models because these effects have not been incorporated into previous analyses. A study designed to measure rural land values is expected to be of interest to appraisers, potential land buyers, farmers, policy makers, lenders, realtors, and others with an interest in agriculture. Other studies have assumed no spatial autocorrelation and used ordinary least squares for estimating hedonic models. However, if spatial dependence is present ordinary least squares estimates are inefficient.

In this study, hedonic modeling procedures, along with spatial econometric procedures, are used to develop a rural land value model for the state of Louisiana. A combination of Geographical Information Systems (GIS) tools and econometric procedures are used to statistically test for the presence of spatial autocorrelation.

Justification

Farm real estate is the most valuable asset on the farm sector balance sheet (currently accounting for more than three quarters of total U.S. farm assets), and its value provides an indicator of the general economic health of the agricultural sector (ERS, 2001). Farm real estate is also the principal source of collateral for farm loans enabling farm operators to finance the purchase of additional farmland and equipment or to finance current operating expenses. Rural real estate values are also important indicators of the financial condition of the rural and, in particular, the farm sector. In addition, rural land values are important to landowners, lenders, tax assessors, prospective buyers, government agencies, and agricultural producers, among others.

In the last decade, there has been an interest in developing a rural land value data base for Louisiana. Kennedy (1995) presented detailed procedures to be used in building a data base for the Louisiana rural land market. In addition, Kennedy and Vandeveer identified rural land submarkets using multivariate procedures and cluster analysis. While these studies represent a step forward in estimating Louisiana rural land values, they ignore the presence of spatial autocorrelation that can result in unbiased, but inefficient estimates. Breaux analyzed the effects that locational and environmental factors had on land values in the Sugarcane Area of Louisiana. In her study, Breaux incorporated several distance variables to account for the effects of location. Breaux did not find problems of spatial autocorrelation in the data set. Cuellar used spatial econometric procedures to estimate rural land values, but her study was limited to the rural land market in Southwest Louisiana.

This study is aimed at developing a detailed analysis of the data base for the Louisiana rural estate market using spatial econometric techniques. The data base will allow for the identification of market relationships, the analysis of economic trends and estimation of their implications in rural land markets. Furthermore, a well designed data base can be used to analyze the effects of inflation, government programs, taxes, urban expansion, interest rates, and technology on Louisiana rural land market values.

Objectives

The primary goal of this study is to conduct a spatial analysis of the dynamics of rural land values in Louisiana. Specific objectives are:

1. Develop procedures for updating the rural land values data base.
2. Test for spatial dependence in the rural real estate data.
3. Empirically estimate land value models using spatial econometric procedures.
4. Estimate the effect that selected other factors have on rural real estate values.
5. Compare and evaluate spatial and traditional rural land value model estimation procedures.

Procedures

<u>Objective One</u>

The first objective of this study is to develop procedures for updating the Louisiana rural land values data base. Data for this study will be collected utilizing the mail survey techniques outlined by Dillman. The method includes mailing the survey, sending a postcard reminder approximately ten days after the initial mailing, and sending a duplicate questionnaire a month after the first mailing.

The questionnaire was sent to commercial banks, the Farm Service Agency, Federal Land Bank, and Louisiana Agriculture Credit personnel. In addition, it was be mailed to members of the Louisiana Chapter of the American Society of Farm Managers and Rural Appraisers and the Louisiana Realtors Land Institute in order to obtain rural land value information.

The questionnaire included three sections. The first section of the survey was designed to collect detailed information on actual sales of rural real estate that occurred between July 1988 and June 2002. Respondents were asked to provide as much information as possible on actual rural tract sales during the survey period. The minimum size of the tract evaluated was ten acres. It will examine tracts located outside the city limits of major metropolitan areas. Sales to close relatives were excluded. In addition to using mail survey techniques, this study developed a method for collecting responses electronically.

Objective Two

Anselin and Hudak proposed three stages in which to implement a spatial econometric strategy for testing and estimation of data in regression analysis. The first stage is the construction of the weight matrix given the spatial arrangement of the observations. The second stage consists of conducting diagnostic tests to check for spatial dependence in regression models. The last stage is the estimation of the spatial regression model using either the appropriate autoregressive dependent variable or a spatial autoregressive structure for the error term.

The second objective of this research deals with the second stage proposed by Anselin and Hudak, which consists of testing for spatial dependence in rural real estate data. At this point, it is important to define the concept of spatial autocorrelation or spatial dependence. In a time series context, the term autocorrelation is well understood, and researchers know how to test for and correct the problem. On the other hand, when using cross-sectional data, the norm is to test and correct for problems dealing with heteroskedasticity. However, it seems obvious that the location of a particular tract will have an effect on its selling price, and will also influence the value of surrounding tracts. If the latter is ignored, it will cause the error terms to be correlated, which is known as a spatial autocorrelation.

Spatial autocorrelation generally has the same consequences as time series autocorrelation in the sense that ordinary least squares (OLS) estimators are unbiased but inefficient, and the estimates of the variance are biased (Dubin). OLS also yields downwardly biased standard errors in the presence of positive autocorrelation (Pace et al.1998b).

Anselin and Hudak propose a test based on the Lagrange Multiplier (LM) principle. The null hypothesis for the LM test states that the classical regression specification is the correct specification, implying that spatial autocorrelation is not present. LM tests also indicate which spatial regression model (lag or error) is the correct model.

Another way to estimate the presence of spatial autocorrelation is by comparing models estimated by OLS and ML spatial procedures. Comparison of OLS and ML models can be made by using measures of fit suggested in the literature. Two of these measures of fit are the log likelihood number and the likelihood ratio (LR) test. The log likelihood numbers from ordinary least squares and maximum likelihood spatial models have to be estimated in order to estimate the LR value. The null hypothesis is that there is no difference between the two models; therefore, a statistical significant estimate for the LR indicates that the spatial error model is better on fitting the data. Additionally, a statistically significant autoregressive coefficient will indicate the presence of spatial autocorrelation. In this study, the LM test, along with the log likelihood numbers and the LR test were used to determine the presence of spatial autocorrelation.

<u>Objective Three</u>

Hedonic pricing models were used to estimate rural land values in Louisiana. Hedonic analysis, which is often used in economic modeling, is specifically designed to value various characteristics that are bundled in one marketable asset or product. This method has been used to study house sales, since a house is sold as a bundle (package) of individual characteristics, such as square footage, proximity to schools, and number of rooms. The importance of this method is that it facilitates estimation of the underlying implicit prices that represents each characteristic's contribution to the overall value of the bundle making up a particular good or service. Therefore, hedonic models can be applied to the analysis of rural land value, as rural land also consists of a bundle of various characteristics that contribute to its value in agriculture use, including soil properties, climate, location, economic development, eligibility for enrollment in government programs, potential for irrigation, and others. There are also other characteristics of rural land that are not agricultural in nature but that contribute to the value of rural land, such as proximities to urban areas and major highways, recreation sites, type of road access, and location relative to a specific scenic area.

Rosen was the first researcher to develop a hedonic theoretical model that could serve as a basis for empirical techniques. His model considers the interaction of consumers and the producers of a differentiated product and the producers of that product. Xu et al. modified the model developed by Rosen to be applied to land value as follows:

$$P(z) = P(z_1, z_2, \ldots, z_n) \tag{1.1}$$

where P is the per acre sale price of a land and z_i represents the contribution of the ith qualitative characteristic related to the land parcel and other relevant market factors.

For rural land value analysis, the hedonic model is formulated, using a transcendental equation, as (Danielson, Kennedy (1995)):

$$\text{Price} = \beta_0 Z_1^{\beta_1} \exp\left[\sum_{i=1}^{m} \alpha_i X_i + \sum_{j=1}^{n} \gamma_j D_j + \varepsilon\right] \tag{1.2}$$

where Price is the per acre price of land, Z_1 is the size of the tract in acres, m is the number of additional continuous variables (X_i), n is the number of discrete (dummy) variables (D_j), and ε is a random disturbance term. Given that the price of land is hypothesized to decline as the size of tract increases, but at a decreasing rate, nonlinearities were incorporated for Z_1 by taking the natural logarithm of both sides of equation 1.2:

$$\ln \text{Price} = \ln\beta_0 + \beta_1 \ln Z_1 + \sum_{i=1}^{m} \alpha_i X_i + \sum_{j=1}^{n} \gamma_i D_j + \varepsilon \tag{1.3}$$

Research has shown that many factors including percent of cropland, percent pastureland, amount of road frontage, value of improvements, percent of mineral rights, presence of government program crop base acreage, paved road access, and general soil type have statistically significant and positive influences on per acre rural land values (Kennedy 1995). Meanwhile, research has shown that other variables, such as percent timberland, size of tract, and distance to largest cities have inverse relationships with per acre values.

Vandeveer et al. also used the Street Atlas USA to compute tract travel time to nearest city and other road travel distance variables. This methodology can be used for estimating the actual distance and traveling time from a tract to the nearest city or town. This procedure is expected to be a more accurate way to estimate distance and travel time than the

GIS techniques which estimate distances on a straight line basis. The authors found that traveling time (as a measure of distance) was highly statistically significant in explaining rural land values.

<u>Objective Four</u>

This objective involves estimating the effects that selected factors have on rural real estate values using marginal implicit prices. Empirically, implicit marginal prices reflect the amount by which the per acre land price changes, given a unit change in the characteristic. By estimating implicit prices, one can observe the magnitude and direction of influence of the attributes at the mean values of rural land price and attribute measured (Elad et al.). Mathematically, marginal implicit prices refer to the partial derivatives obtained from equation (1.2) given by the following:

$$\frac{\partial \text{Price}_t}{\partial Z_{1,t}} = \text{MIPSIZE}_{1,t} = \left[\frac{\beta_1}{Z_{1,t}}\right] \times \text{Price}_t \qquad (1.4)$$

which is the partial derivative of the price formula with respect to the size of tract Z_1, and by the partial derivative of the price with respect to continuous variables (X_i), given by:

$$\frac{\partial \text{Price}_t}{\partial X_i} = \text{MIPX}_{i,t} = \alpha_i \times \text{Price}_t \qquad 0 \qquad (1.5)$$

where t refers to the implicit marginal prices associated with each land transaction.

Implicit prices for discrete variables (D_j), can be derived using the variance of the coefficient as suggested by Kennedy (1981):

$$\frac{\partial \text{Price}}{\partial D_j} = \text{MIPD}_j = \left(\exp\left[c_j - \frac{1}{2}V\left(c_j\right)\right] - 1\right) \times \text{Price}_t \qquad (1.6)$$

where $MIPD_j$ is the marginal implicit price of discrete variables, c_j is the estimated coefficient of the discrete variable parameter, $V(c_j)$ is the variance[2] of the estimated coefficient, and Mean Price is the mean price per acre over all of the observations used in the model. According to Kennedy (1981) calculating $V(c_j)$ can lead to less bias in the estimate when the variance of c_j is large.

Objective Five

The last objective of this study was to compare and evaluate spatial and traditional rural land value estimation procedures. In the past, the difficulties of applying spatial statistics limited its scope and appeal. However, with the advances in computing, algorithms, and software, it is now possible to conduct spatial models with a large number of observations in a minimal amount of time (Pace and Barry, 1997a).

Dubin studied some of the issues involved in estimating house pricing models with spatially autocorrelated error terms. The author used a hedonic pricing regression model to consider the spatial autocorrelation problem. The study then compared and contrasted the results to the most commonly used techniques. In her study, Dubin modeled the autocorrelation structure using two methods. One approach required the use of a weight matrix, and the other method modeled the covariance matrix of the error terms directly. Dubin discovered that modeling the error term under the presence of spatial autocorrelation dominates a model which ignores the problem completely.

Pace et al. (1998a) emphasized the importance of applying spatial statistics to real estate data. They recognized that the use of "spaceless" statistical tools can result in clusters

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[2] $V(c_j)$ can be obtained from the standard error and the model estimates once the spatial model has been conducted.

of residuals of one sign or another along roads, i.e., neighborhoods, because the independence assumption under OLS is violated. Pace and Barry (1997b) computed a spatial autoregressive model (SAR) and compared their results to those of the OLS model. The authors computed SAR using 20,640 observations on housing prices in California. They found that the spatial autoregressive estimators greatly outperformed ordinary least square estimators.

Vandeveer et al. employed spatial econometric procedures to analyze rural land values in Louisiana. Statistical tests indicated improved results for the maximum likelihood spatial error and spatial lag models over models estimated using OLS procedures. Statistical measures of fit also suggested that spatial econometric models provided an improved measure of fit over OLS procedures.

In this objective, statistical measures of fit were used to compare and evaluate spatial and traditional rural land value model estimation procedures. Specifically, log likelihood numbers and the likelihood ratio test were used to compare between OLS and ML spatial models. In addition, marginal implicit prices for land characteristics obtained by OLS and ML spatial models were compared.

Outline of the Dissertation

The study is divided into six chapters. Chapter one includes the introduction, problem statement, justification, objectives, and general procedures. Chapter two includes theory and literature review on economic theory to support the techniques used in this study. Chapter three includes detailed information on the econometric methods and procedures this study followed. Chapter four presents a review of the methods used to conduct the Rural Land Market Survey, as well as descriptive statistics from the survey. Chapter five presents the results from the hedonic pricing model. Chapter six includes a summary of the findings of the study, conclusions, limitations, and recommendations.

CHAPTER 2 . THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Land can be seen as space, nature, a factor of production, a consumable good, situation, property or capital. Land considered as space includes all the space on and under the surface. As nature, land is considered a natural resource. It is also a factor of production as a source of food, fiber, building materials, minerals, energy resources, and other raw materials. Buildings, parks, recreation and residential properties are treated as consumption goods. Situation refers to location of land with respect to markets. Land as property involves real estate and has legal connotations. Land can be viewed as a type of capital because it is a resource that is purchased or leased like other capital goods (Barlowe). All these facets of the land are compiled in different fields of economic theory and help in explaining variations in land values. More specifically, location theory, economic development theory, and theory of the firm are economic tools used to explain variability in land values.

This study analyzes the dynamics of rural land values in Louisiana. Therefore, the first part describes the rural land real estate market and some of the main features that influence rural land values. The second part explains the economic theory that helps to explain land value variations. This section includes the concept of land rent according to classical and neoclassical theory. The third part studies the process of valuation and appraisal of real estate. In addition, since the land markets are heterogeneous in nature, hedonic price models are used to estimate rural land values. Consequently, the fourth part of this chapter explains the economic nature of the hedonic price model applied to rural land. The fifth part of this chapter presents the pertinent spatial statistical theory applied to this research. Finally, the last section presents a review of the literature on models and econometric procedures used to estimate land values.

The Rural Real Estate Market

When applied to economics, the term "land" refers to land resources[3] or real estate rather than just land. These terms are used because they include manmade improvements such as buildings and other capital improvements attached to the land as well as the natural characteristics of the land.

According to Barlowe, land can be classified according to its use. Several classifications used for principal types of land use, such as residential, commercial, industrial, crop, pasture, timber, mineral, recreation, transportation, service areas, barren and waste, are based on the way they affect the market value. The most workable uses for rural land are cropland, timberland, pastureland, and recreation land. Cropland includes the areas used in the production of food, fiber, feed, and other crops. Pastureland includes improved and rotation pasture areas. Timberland includes areas used for commercial timber production and non-commercial woodlands, farm woodlots, cutover lands with a timber growth potential, and brushland areas. Recreation lands, in the rural concept, include parks, beaches, open space for hunting, and scenic areas that are used mainly for recreation and closely related purposes. However, with the pressure for development at the rural-urban fringe, residential, commercial, and industrial types of land are also important for evaluating rural land values because they involve areas subject to the most intensive human use and sites of highest market value.

Two important concepts that could be used to explain rural land values are land use capacity, and highest and best use of land. Land use capacity involves all the factors that affect a unit of land resource to produce a surplus of returns as compared with some other

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[3] A more detailed discussion of this can be found in Barlowe.

unit. Accessibility and resource quality are two components of use capacity. Accessibility has to do with the optimization of transportation and communication costs and time distance considerations. With agricultural lands, resource quality relates to the native fertility in combination with the ability to respond to fertilizer inputs. Highest and best use refers to land that is used in a manner that provides an optimum return to their operators or society. Highest and best use of any particular site and land use capacity shift with changes in quality of the land resource, changes in technology, and changes in demand (Barlowe).

Land in the center of a city could be used for anything including agricultural purposes. However, owners of land will use land for whatever use brings the highest returns. In this sense, owners allocate land to its highest comparative advantage or best use. Highest or best use can change due to local or national policy, changes in quality of the land, changes in technology, and changes in demand. The highest returns are usually related with commercial and industrial land, located near the center of the city, followed by residential land, and agricultural land.

In general, the highest and best use can be quantified in monetary terms, using market price mechanisms. However, in some instances, social concepts of the highest and best use, such as goals and value judgments, are important.

Allocation of land resources is still mainly accomplished through the market system. The real estate market can be defined as the arrangement by which buyers and sellers are brought together to determine a price at which a particular tract can be exchanged (Harrison et al.). The function of the real property market is to establish a pattern of prices and rents so that, in the long run, land resources are allocated according to their higher and best use relative to other land resources. The efficiency of the real estate market in the economy may be impaired because the conditions for a perfectly competitive market do not hold. For example, there is a lack of perfect knowledge in the real estate market that can lead to different forms of pricing, such as the process of trial and error, auction, or tender (features of a property that are appealing to a particular operator).

Basic economic theory states that the price[4] of a commodity can be determined by the supply demand equilibrium model. Unlike other factors of production, the amount of rural land available for production is expected to be fixed in the short run. In the short run, the supply of land is perfectly inelastic as shown in Figure 2.1. The demand for land is said to be a derived demand because it depends on the intensity of the demand for products of land, like food and fiber, aesthetics, or other valued quality, and not just because of the land. With the quantity of rural land fixed, the demand equation entirely determines price.

The single most important factor that affects demand for land and its products are population numbers (Barlowe). Other demand factors for agricultural land besides population numbers are nutritional and other consumption standards, and land productivity. For example, in Figure 2.1, an increase in population will shift the demand for land, from D to D_1, and the price of land will increase from P to P_1.

Higher total population numbers mean greater demand for agricultural and non-agricultural land because people will need schools, factories, shopping centers, streets and parks. These needs call for new residential, commercial, and industrial development and for land areas that can be used for recreation, transportation, and service purposes. Because of their higher than average values, commercial and industrial, residential and other urban-

[4] When referring to agricultural land, price represents the amount a particular purchaser agrees to pay and a particular seller agrees to accept given the circumstances under which the tract of land is sold. Land value, on the other hand, represents the monetary worth of the property, goods, or services to buyers and sellers.

oriented uses can secure additional land by bidding it away from agriculture and other open-space uses (Harvey).

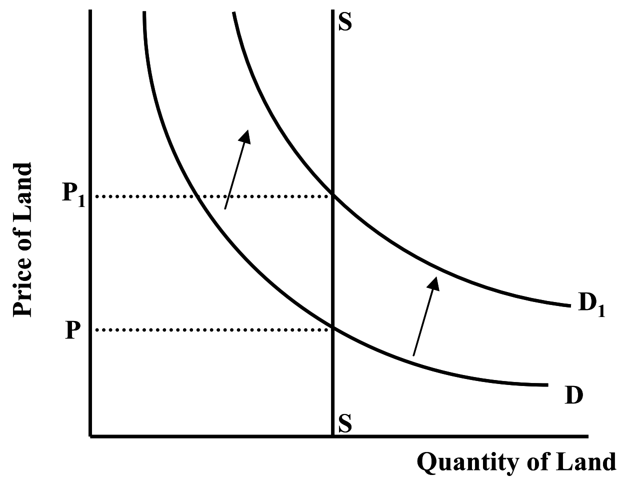

Figure 2.1. Supply and demand of land in the short run, assuming a fixed supply of land.

Land Rent

Land rent represents the economic return that goes to real estate resources for their use in production (Barlowe). It is an important concept in land value because it affects taxation policies, leasing arrangements, land development, and other aspects of land resources. Land rent influences the allocation of land resources between individuals and between competitive uses.

Land rent is usually viewed as a residual surplus; the portion of total returns that remain after payment is made for total costs including residual returns to management and risk. This is obtained by using the marginal-productivity approach. The marginal productivity approach uses cost curves to estimate net returns. In turn, the costs curves are derived from the marginal and average value product curves that are based on the production function. Figure 2.2 shows the economic rents derived from the cost curves of a representative production situation. The average cost curve (AC) of producing q units of output initially declines, but, due to diminishing returns, it eventually must rise. Assuming perfect competition, and if the price of q is p, the firm will produce at a level of output where price equals marginal cost (MC). The land rent corresponds to the shaded rectangle in Figure 2.2.

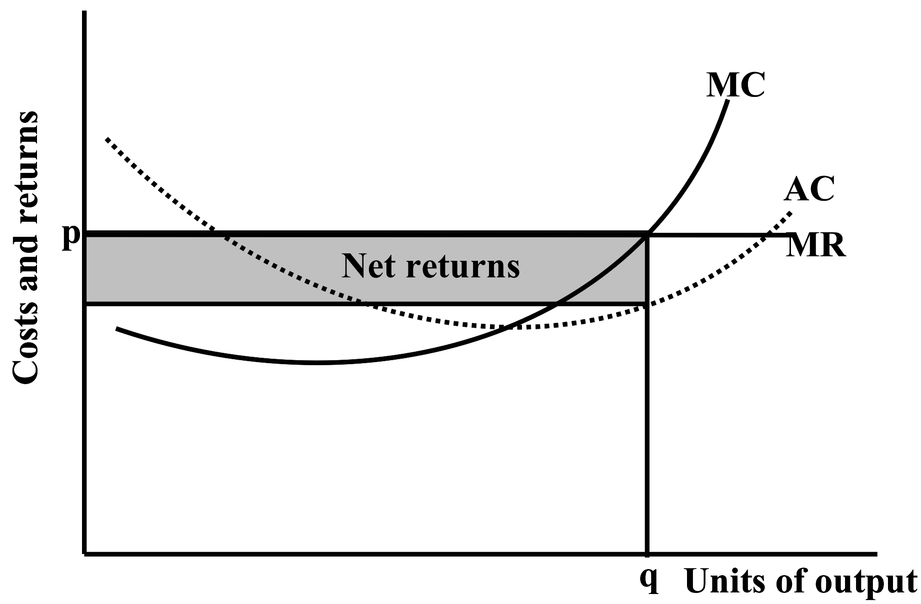

Figure 2.2. Land rent depicted from the land-productivity approach.

Several factors can affect land rent. In general, holding other things equal, average cost of production per output unit yields different rents in different tracts of land. With higher prices or lower costs, rents rise, and in turn, with lower prices or higher costs, rents decrease. The weakness of this type of approach is its assumption that returns to other factors (other than factors of production) can be determined with some degree of precision. However, this assumption is not often warranted.

Rent Arising from Differences in Soil Fertility

Originally, the concept of rent was associated with land only. One of the classical notions of land rent that made significant contributions to present land rent theory was developed by David Ricardo. Barlowe and van Kooten mention the approach that Ricardo used to estimate land rents. In Ricardo's approach, there is a newly settled country with very rich and fertile land of which only a small proportion is required to supply the population's needs. Initially, there are no rents associated with the use of land because only the most fertile lands would be cultivated.

According to Barlowe, Ricardo's approach can be illustrated using costs curves in Figure 2.3. This example assumes four different types of land based on their fertility: A, B, C, and D. When only lands of type A are used and price is p_1, the operator finds it profitable to produce q_A^1 units of output, and no rent is generated. As the price of output rises to p_2 due to increases in population, the less fertile land B would be brought into production. The operators find it profitable to produce q_B^1 units of output, and no rent is generated by producers using land B. When less productive land is brought into production, this implies that the owners of land A will earn a differential rent (shaded area in land A), when producing q_A^2 units of output. Likewise, when less fertile C lands come into use (at a higher price p_3), operators of lands B will produce q_B^2 units of output and will get rent. Operators of lands A will produce q_A^3 units of output and will receive a larger rent. Finally, when the price of the output rises to p_4, D lands are brought into cultivation, and the operators of the more fertile lands find that they can earn additional rents by increasing their production to yield additional units of output. The Ricardian definition of land rent has been criticized

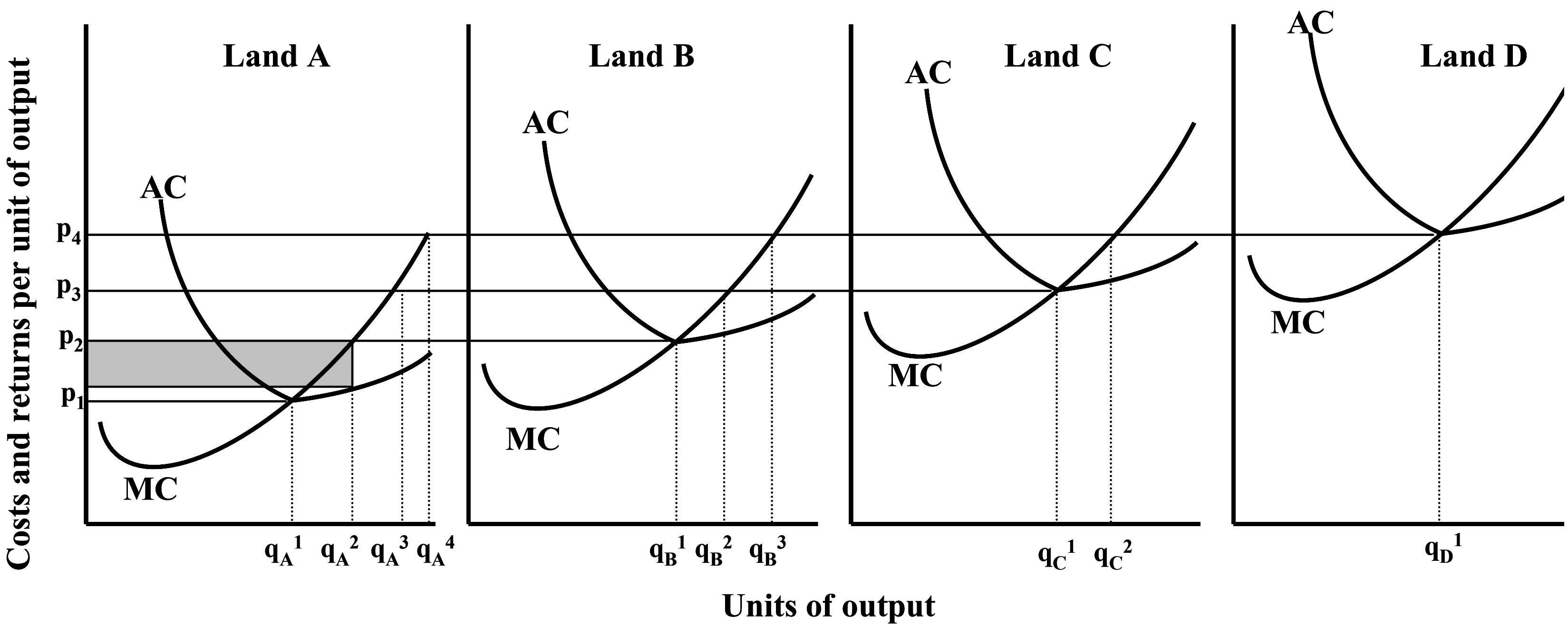

Figure 2.3. Ricardo's approach to land rent, based on fertility of the land, using cost and returns curves. Adapted from Barlowe.

because it ignores changes in the organization of production, additional effort, or additional outlays on inputs as prices rise (van Kooten).

Location Theory

The perfectly competitive market assumes that buyers, sellers and products have perfect mobility. However, land resources are fixed in space located at different distances from centers of economic activity. Therefore, products, capital, and labor have to move to and from the land and this process involves costs. Location helps to determine land use and value levels associated with its use.

Location theory is a theoretical framework for studying location decisions made by firms and households that is based on transportation costs and spatial differences in the accessibility of inputs and markets for outputs. Modern developments in location theory are extensions of the classical models from August Losch, Alfred Weber, Johann von Thünen, Walter Christaller, and Walter Isard. These classical models of location theory explicitly consider cost of transportation in production and consumption choices made by firms and households (Butler). Location theory has been used to explain urban density, labor migration, and land use.

There are four classical traditions on location theory: the land use model, the industrial-location production orientation model, the central market place model and the spatial competition model. All four models are based on classical or neo-classical deductive micro-economic reasoning.

In terms of land use, Johann Heinrich von Thünen, a farmer with knowledge in economics, made distance to market the main variable in explaining the spatial pattern of agricultural land use. Von Thünen argued that rent was a function of location and not of land fertility, as stated by David Ricardo (von Thünen). Von Thünen's model is based on the following limiting assumptions: 1) the Isolated State (final market) is located centrally, is self sufficient and has no external influences; 2) the Isolated State is surrounded by an unoccupied wilderness; 3) the land of the State is completely flat and has no rivers or mountains to interrupt the terrain; 4) the soil quality and climate are consistent throughout the State; 5) farmers in the Isolated State transport their own goods to market via oxcart, across land, directly to the central city and therefore, there are no roads; and 6) farmers act to maximize profits. In this model, all factors affecting land use were kept constant except location and distance to market.

Von Thünen proposed that in the case of a final market (Isolated State), agricultural production patterns would form a series of concentric rings. These rings would reflect the costs of transportation. Perishable commodities would be produced in the inner rings, and those commodities that could be stored and are easily transported would be produced in the outer rings. In this model, at each location, a rent per unit of land would be bid equal to the value of the crop less cost of production and transportation to the market. Two primary conclusions from the model are that land values decrease as distance from the central point of attraction increases and that different land use activities are contained in concentric rings equal distance from the central point of attraction based on the weight (or transportation cost) of the activity (Miranowski and Cochran).

Several works on spatial economics have been inspired by von Thünen's idea (Krugman). His model has been modified by Dicken and Lloyd to explain the spatial organization of land use. Figure 2.4 represents a basic location-rent model in which land use is allocated around a central market. Straight lines represent rents for different services of land as a function of location. Rents are expected to decrease as distance from market and

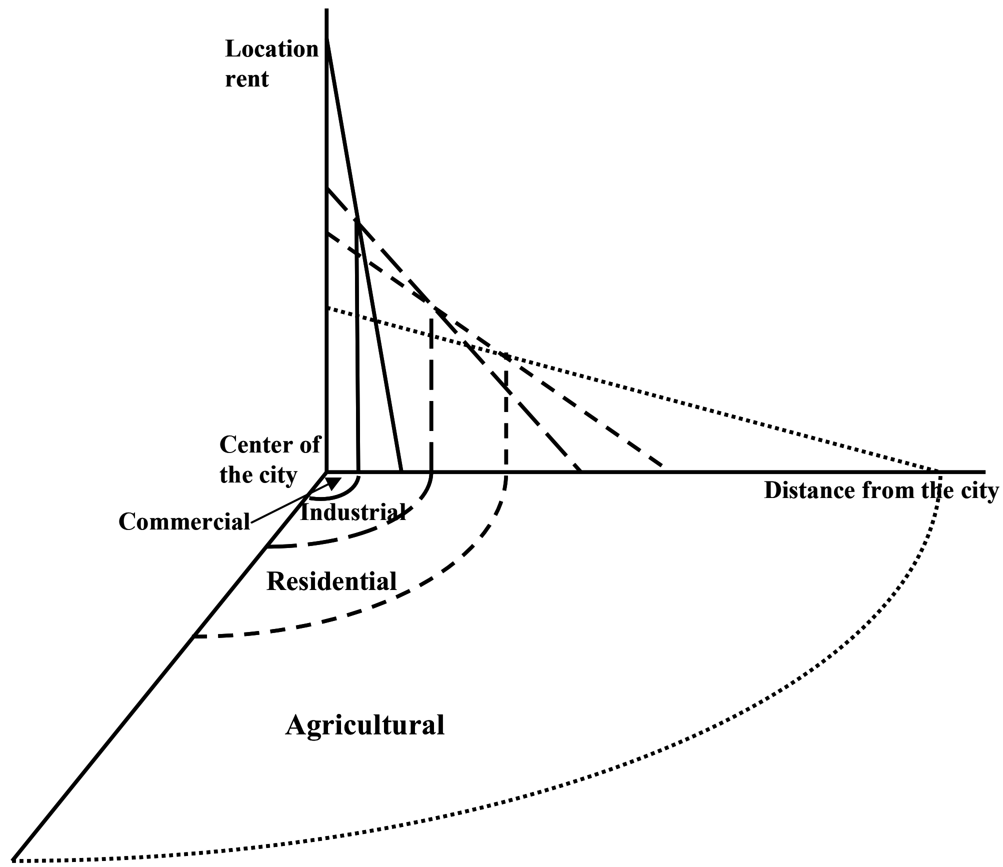

Figure 2.4. Relationship between location rent and spatial organization of land uses. Adapted from Dicken and Lloyd.

transportation costs increase, which is represented by the downward sloping lines. Through competitive bidding, steeper rent curves produce higher rents and result in locations closer to the center of the city. Therefore, land closer to the center of the city receives higher rents and higher capitalized values than areas located a greater distances from the city centers.

In general, a combination of theories including marginal productivity, location, and economic growth theories is necessary to explain valuation in rural land markets. The concept of comparative advantage becomes useful for putting these theories together to explain valuation in rural land markets. According to Barlowe, comparative advantage not only comes from natural resource endowment, but also comes from favorable combinations of production inputs, location and transportation costs, favorable institutional arrangements, and desired amenity factors. Therefore, not only site characteristics, but locational and economic development factors are expected to affect land use and highest and best use of land.

Valuation and Appraisal of Real Estate

Valuation is the process of estimating the value of a tract of land at a given date (Harrison et al.). According to Barlowe, there are three principal types of real estate market valuation procedures: the market approach, the income capitalization approach, and the replacement-cost approach.

<u>The Market Approach</u>

According to the market approach, appraisers determine the expected price of a tract by comparing its value characteristics and sales circumstances with those of similar properties that have been sold recently. This approach relates appraised values to current supply and demand conditions. One problem with the market approach is that comparable properties may be scarce due to a relatively inactive real estate market, or because the local market is small. Market comparability requires special attention to the location, conditions, and time of the benchmark property sale. Once the appraisers obtain the relevant data on comparable properties, they proceed to look for similarities and dissimilarities among properties. For example, in agricultural land, appraisers may look for improvements to the land, road type accessibility, and existing crop production. The market approach works well when farms are comparable to other properties that are sold in sufficient numbers to provide a basis for comparisons (Harrison et al.).

The Income-Capitalization Approach

The majority of inputs used in the production process can be seen as one time use or application. Therefore, that resource is worth what it can produce per unit of time. However, land resources, such as farms or forestland can be seen as productive factors with almost unlimited productive life. This is why net returns earned by land resources occur as an annual flow throughout their productive life (Cramer and Jensen). Capitalization is a method used in the income-capitalization approach to convert a single year's income into a value indication (Harrison et al.). Any interest in real estate that has an income stream can be valued by the capitalization formula:

$$\text{Value of land} = \frac{\text{Estimated average annual rent expected in the future}}{\text{Interest rate}} \qquad (2.1)$$

Estimation of average annual land rent presents some problems for the appraisers. Farm appraisers usually consider the physical resource base of the farm, productivity of the soil, and average crop yields for the preceding five to ten years. Appraisers also obtain information on the typical cropping system to provide a picture of overall productivity of the farm. Estimated commodity prices are used to compute the average expected gross income. Then the appraiser subtracts estimated operating expenses from estimated gross income to determine the land rent attributable to land and buildings.

The Replacement-Cost Approach

The replacement-cost approach is based on production costs and value. The assumption is that properties should be worth their present replacement costs less an allowance for depreciation and possible obsolescence. The approach sets an upper limit on property value. However, lack of perfect knowledge results in sales above this limit. This valuation method is used basically in the appraisal of residential and certain other urban properties.

While both theory and appraisal valuation methods provide important information concerning valuation in real estate markets, they do not provide the basis for analyzing and explaining variation of the factors that influence rural real estate values. The actual rural land market depends on several factors other than the capitalized value of its future income stream. The appraisal approach yields subjective assessments of the values of the characteristics based on comparable cases. On the other hand, the hedonic approach yields objective empirical estimates of the values of a tract of land and locational characteristics (Miranowski and Hammes).

Hedonic Model

In the competitive market, prices are determined by the supply and demand equilibrium. The supply and demand model is widely used and straight forward for homogeneous goods such as agricultural commodities of a particular type, like sugar and wheat. However, when commodities are heterogeneous in nature, this analysis is not as useful. For example, in the urban real estate market there are differences among houses such as number of bedrooms, lot size, age of the house, and number of square feet. However, appraisers talk about a market for houses in a particular area. The model that allows for heterogeneous goods to be sold in a single market, while allowing some characteristics to vary, is the hedonic price model. How the economic value of several rural land characteristics, such as size of the tract, type of soil, government programs, and type of crops, is inferred is not any different from the urban real estate market in the sense that these are nonmarket characteristics of rural land. Therefore, hedonic price modeling is used to assess rural land values as well.

Formally, a hedonic regression is one in which price of a good is regressed on its attributes. The resulting coefficients reflect the implicit prices of the attributes (Palmquist). Rosen developed the most widely used model of equilibrium with a heterogeneous good. As described by Palmquist, it is assumed that there is a perfectly competitive market for the tract of land with characteristics:

$$Z = z_1,z_2,\ldots z_n \tag{2.2}$$

Each characteristic is valued as the market equilibrium values it. In general, the price for the heterogeneous product is related to the characteristics of the product and it is given by the hedonic equation:

$$P = P(z_1,z_2,\ldots z_n) \tag{2.3}$$

If one can estimate (2.3) from available data, then the coefficients of the models can be used to determine the implicit price associated with each characteristic of a tract of land, holding all other things constant (Carlson et al.). For example, if characteristic z_1 of the tract measures the distance to the nearest city in miles, then the price per mile is the partial derivative of Equation 2.3 with respect to characteristic z_1, distance to the nearest city,

$$\frac{\partial P}{\partial z_1} = \frac{P(z_1,z_2,\ldots,z_n)}{\partial z_1}. \tag{2.4}$$

Some characteristics of the hedonic function is that it only depends on the characteristics of the product, and not on information about the buyer or seller of the product. The functional form for the hedonic equation is probably nonlinear. The hedonic equation is assumed to be the result of the actions of consumers and producers. The hedonic model summarizes the equilibrium relationship between market price and the characteristics of the property. Finally, for the purposes of property assessment and determination of price indexes, this model is sufficient.

Hedonic regression analysis has played an important role in urban economics, particularly in housing market studies where a large of number of articles is found. Some examples include using hedonic analysis to measure the value of reducing air pollution (Ridker and Henning), effects of erosion on farmland values (Palmquist and Danielson), to determine the effect of school integration on housing prices (Jud and Watts), and to determine the effect of racial discrimination on housing prices (King and Miezkowski).

Spatial Statistics and Rural Land Values

Multivariate techniques have been used to estimate land value as a function of physical, economic, social, and political factors. The variables are quantified and a regression model is used to specify how these factors might influence land price and to test and calibrate such models using sales data. These models can serve as exploratory tools, but with advances in GIS techniques and spatial econometrics, they are not accurate predictors of land value. Despite frequent mentions in the literature of violation of the assumptions that ensure the optimality of such tools, the majority of empirical research has ignored the spatial statistical tools.

The advent of geographical information systems has changed spatial data visualization, management and analysis (Clapp et al.). GIS techniques have been used to understand the distribution of land value and how such tools can be used to support different land policies (Azar et al.). GIS includes technology that can assign latitude and longitude to property address information, which is used in the construction of spatial weight matrices (Anselin, 1988). In addition, the advances in computing, algorithms, and software make possible the use of spatial econometric routines. Employing spatial statistical estimators improve prediction since ordinary least square estimators yield downwardly biased standard errors in the presence of positive spatial autocorrelation.

Spatial Analysis

It is a natural assumption to say that data close together in space are likely to be correlated (Cressie). According to Griffith (1988, 1992), in a literal sense, spatial autocorrelation refers to the dependence that exists among observations due to relative locations. These dependencies produce the clustering of similar (positive spatial autocorrelation) or different (negative spatial autocorrelation) values. Goodchild says that spatial autocorrelation can be defined as a technique that deals simultaneously with both attribute and locational information. Attributes of spatial features include measures such as size, value, and population, as well as qualitative variables such as region and soil type. Locational attributes can be described by geo-referencing the data using, for example, coordinates.

Anselin (1988) defines spatial autocorrelation[5] as the situation where the dependent variable or error term at each location, is correlated with observations for the dependent variable or error term at other locations. Spatial autocorrelation can be expressed by the moment condition:

$$\mathrm{Cov}\left[y_i, y_j\right] = E\left[y_i, y_j\right] - E\left[y_i\right] \times E\left[y_j\right] \neq 0 \quad \text{for } i \neq j \qquad (2.5)$$

where i, j are individual observations (locations) and y_i, y_j are the values of a random variable of interest at that location.

<u>The Spatial Lag Model</u>

This spatial autoregressive model measures the dependence of values at each location on values at neighboring locations. Intuitively, using spatial statistics is a way to empirically

[5] Anselin (1995) uses the terms spatial autocorrelation and spatial dependence interchangeably. The two are not identical, but typically, the weaker expression is used, in the sense of a moment of a joint distribution.

estimate land values associated by location, similar to the subjective way appraisers use when they compare values of land in similar regions.

The spatial lag model includes a spatially lagged dependent variable, Wy, in the right hand side (RHS) as part of the set of explanatory variables:

$$y = \alpha Wy + X\beta + \varepsilon \tag{2.6}$$

where y is an n by 1 vector of observations on the dependent variable, Wy is an n by 1 vector of spatial lags for the dependent variable, α is the spatial autoregressive coefficient, X is an n by k matrix of observations on the explanatory variables, β is a k by 1 vector of regression coefficients, and ε is an k by 1 vector of normally distributed random error terms, with a mean zero and a constant variance of σ^2.

<u>The Spatial Error Model</u>

The error term in a statistical model is an unobservable random variable representing the effects of all those unexplained factors that cause land values to differ from the population mean. The rural land market is complex and it is very difficult to model all variables affecting land values. The error term accounts for omitted variables, an incorrect functional form, and inadequate sampling. In house pricing models the error term also accounts for a "transaction error" that represents the difference between transaction prices and the expected market price relative to other houses in the market (Can and Megbolucbe). Like an appraiser, the spatial error model uses the correlated errors on nearby properties to improve the overall prediction.

If the error at each location depends on the errors at other locations, then it is said that the errors are spatially autocorrelated. In this case, the assumptions of homoskedastic and uncorrelated errors are not satisfied. There are many forms of spatial dependence in the error term, but usually, a spatial autoregressive process for the error term is estimated. This model is the standard regression specification with a spatial autoregressive error term:

$$\begin{aligned} y &= X\beta + \varepsilon \\ \varepsilon &= \alpha W\varepsilon + \xi \end{aligned} \tag{2.7}$$

where y is an n by 1 vector of observations on the dependent variable, X is an n by k matrix of observations on the explanatory variables, β is a k by 1 vector of regression coefficients, ε is an n by 1 vector of error terms, $W\varepsilon$ is a spatial lag for the errors, α is the autoregressive coefficient and ξ is the error vector with a mean of zero and constant covariance of $\sigma^2 I$.

<u>Maximum Likelihood Estimation</u>

It has been well documented in the spatial econometrics literature that estimation with ordinary least squares in the presence of autocorrelation is not appropriate (for example Ord; Pace et al. 1998a; Anselin 1988). Ord was the first who outlined the maximum likelihood estimation of spatial lag and spatial error regression models.

The spatial lag model is also known as the simultaneous spatial autoregressive model (SAR) lag model because the presence of the spatial lag is similar to the inclusion of endogenous variables on the RHS in systems of simultaneous equations. In systems of simultaneous equations, the inclusion of endogenous variables in the RHS of the specification causes ordinary least squares to no longer achieve consistency, so estimation is based on an instrumental variable approach. This is also the case for the spatial lag model. According to Pace and Barry (1997c), if the autoregressive parameter were known, the model would simplify to a standard regression of filtered dependent variables $y - \alpha Wy$ on the explanatory variables X as follows:

$$y - \alpha Wy = X\beta + \varepsilon \tag{2.8}$$

However, because the α coefficient is usually unknown, it must be jointly estimated with the regression coefficients. The main reason for inclusion of Wy in the RHS of the specification is because ordinary least square is no longer consistent. This is similar to what happens in systems of simultaneous equations.

The log-likelihood for the spatial lag model takes the form:

$$\begin{aligned} \ln L = \ln\left|I\text{-}\alpha W\right| - \left(\frac{N}{2}\right)\ln(2\pi) - \left(\frac{N}{2}\right)\ln\sigma^2 \\ - \left(\frac{1}{2}\sigma^2\right)\left(y\text{-}\alpha Wy\text{-}X\beta\right)'\left(y\text{-}\alpha Wy\text{-}X\beta\right) \end{aligned} \quad (2.9)$$

The minimization of the last term in (2.9) corresponds to ordinary least squares, but since it ignores the Jacobian $\ln\left|I - \alpha W\right|$, ordinary least squares is not a consistent estimator in this model. The estimators for the parameters must be obtained from an explicit maximization of the likelihood (Anselin 1988, Pace et al. 1998a).

In the case of the spatial error model, the error term no longer has the usual diagonal matrix, but instead the variance takes the following form:

$$E[\varepsilon\varepsilon']=\Omega=\sigma^2[(I\text{-}\alpha W)'(I\text{-}\alpha W)]^{-1} \quad (2.10)$$

The log-likelihood for the spatial error model can be expressed as:

$$\begin{aligned} \ln L = \ln\left|I\text{-}\alpha W\right| - \left(\frac{N}{2}\right)\ln(2\pi) - \left(\frac{N}{2}\right)\ln\sigma^2 \\ - \left(\frac{1}{2}\sigma^2\right)(y\text{-}X\beta)'\left(y\text{-}\alpha Wy\text{-}X\beta\right)'\left(y\text{-}\alpha Wy\text{-}X\beta\right)(y\text{-}X\beta) \end{aligned} \quad (2.11)$$

The ordinary least square estimator is still unbiased, but no longer efficient. Threfore, inference based on biased ordinary least square estimators for the variance and model fit may be misleading. There is no consistent two-step estimator for the spatial error model; therefore, the only alternative is the maximum likelihood estimation (Anselin and Hudak).

Spatial Weight Matrices

According to Anselin and Hudak, a unique characteristic of spatial econometrics is that the spatial arrangement of the observations is made explicit by using a spatial weight matrix denoted by W. Through computer software, the spatial weight matrix is used in econometric analyses in three ways. The first use is for creating spatially lagged variables as the product of the weight matrix with the vector of dependent variables (Wy), the matrix of explanatory variables (WX), or the vector of residuals ($W\varepsilon$). The second use is for the computation of various standardization coefficients used in tests for spatial autocorrelation, like the Moran's I and the Lagrange multiplier tests. The third use of the spatial weight matrix is in calculation of the Jacobian determinant $|I - \alpha W|$ (I is the identity matrix and α is the autoregressive parameter) in the likelihood of spatial autoregressive processes (Anselin 1988).

Some of the general characteristics of the weight matrix is that the rows and columns of this matrix correspond to the observations. The nonzero elements for a row-column pair reflect the strength of the potential interaction between two locations in a general spatial weight matrix. The elements of the weight matrix are often used in a row-standardized form implying that the row elements of the matrix (w_{ij} where j is a near neighbor of i) of a standardized matrix sum to one (Haining). The standardization is obtained by dividing each w_{ij} by the row sum (Ord; Odland; Anselin 1988):

$$w_{i*} = \sum_j w_{ij} \tag{2.12}$$

By convention, w_{ii} equals zero (the observation cannot predict itself).

There are several procedures in the specification of the spatial weight matrix. Misspecification of the weight matrix can result in inconsistent estimates and misleading inference (Stetzer). Dubin et al., explained two general ways to specify the spatial weight matrix. Using latitude and longitude, one can calculate a distance matrix. The main diagonal of zeros implies that the distance between one house and itself is zero. The other general way of defining a weight matrix is by the lattice model approach. Instead of distances, this approach finds the nearest neighbors to each observation.

Empirical Estimation of Land Values: Literature Review

Different models employ different variables for estimating land value. These differences come from economic theory and social and physical aspects of the rural land. Most studies of agricultural land values in the last three decades have explained prices in terms of discounted sum of net incomes or economic rents from farming the land, putting special emphasis on interest rates, inflation, and speculative bubbles. Therefore, the value of land depends on the discount rate and the number of years considered. This relationship is represented by a formula similar to Equation 2.1:

$$\text{Value of land} = \sum_{i=1}^{n}\left[\frac{a_i}{(1+r)^i}\right] \tag{2.13}$$

where a_i is the expected annual rent, r is the annual interest rate, and n is the number of years.

Burt developed econometric modeling of farmland prices using the capitalization formula. Since the study focused on a homogeneous agricultural area, high crop-share grain lands in Illinois, the study quantified farmland prices using econometric time-series methods. The data set was very unique because the net returns used to estimate the rents were from farm accounting data in which accounting procedures were uniform during the thirty years of data collection. The author found that neither the expected rate of inflation nor an exponential trend on rent expectations had a significant effect on land prices. Burt concludes that deviations of farmland prices from its fundamental path can be explained in terms of overreaction to rent movements.

Plantinga and Miller tried to identify the influence of future development on agricultural land values using the capitalization formula. The authors used a second-order approximation to model the nonlinear relationship between land values and the explanatory variables. These nonlinear relationships were approximated using polynomial functions. They used cross-sectional and time-series data on 54 counties in New York for three years. They found that, as expected, counties with higher agricultural rents have higher land values. Also, higher population growth in the closest and second closest metropolitan areas increased land values by increasing development rents. Finally, they found that land values declined as travel time to the closest metropolitan area increased, but land values increased as travel time to the second closest metropolitan area increased.

Adrian and Hardy conducted a rural land market analysis to estimate land values in Alabama. They estimated the bare land value per acre using ordinary least squares procedures. The authors found that the bare land value per acre depended on a curvilinear response to tract size, distance to metropolitan area, and time. Later, Adrian and Cannon looked at shifts in agricultural land uses and values and values at the periphery of a metropolitan area in Alabama. The authors used a pooled cross-sectional and time-series data set collected from a survey. Variations in bare land values per acre were specified as being a function of variables broadly classified as locational, physical, and sale variables. The authors used ordinary least squares procedures. They concluded that locational factors were the most significant in the fringe and the urban sectors. They also found that the influence of physical characteristics of the land, such as size of the tract and acres of row crop, on land value was more apparent in the rural analysis model.

Hedonic Model for Estimating Land Values

An alternative approach to assessing agricultural land values that has received increasing attention in recent years focuses on the implicit or hedonic price approach. The reason for using hedonic models instead of using models based on Equation 2.5 is that the market value of land depends on several factors other than the capitalized value of its future income stream. Additionally, the major distinction between the appraisal and implicit price approaches to valuation is that the appraisal approach yields subjective assessments of the values of characteristics based on comparable cases, while the implicit price approach yields objective empirical estimates of the values of particular land and locational characteristics (Miranowski and Hammes).

In an early study, Hushak and Sadr placed emphasis on dropping the assumption of “featureless” space in the von Thünen model by using space to explain land values. The authors used a transcendental function to explain changes in land values. Results showed that the transcendental function provided relatively stable results, both within and across data sets, because it allows for nonlinear relationships, in particular parcel size. On the other hand, arithmetic functions resulted in different price response estimates, within and across the data.

Elad et al. used hedonic pricing techniques to make explicit the impact of implicit farmland attributes that contributed to the value of farmland in Georgia. The authors used primary data from surveys over the period of 1986 to 1989. For this study, an unrestricted Box-Cox model, estimated by maximum likelihood procedures, was used for the analysis. The authors concluded that characteristics of farmland could differ markedly in importance and direction of influence on marginal implicit prices and thus farmland values depending on regional location.

Miranowski and Hammes used hedonic models to estimate the effects of soil type on farmland values in Iowa. The authors used a linear functional form to estimate the models. They concluded that increased topsoil depth and pH had a positive impact on land values, while potential erosion had a negative effect on land values.

Xu et al. used the hedonic approach to determine the relationship between land values and parcel characteristics to explain and predict the differences in land values attributable to differences in the levels of parcel characteristics. The authors used gross income, soil productivity, irrigation, buildings, distance to town, and size of the parcel, as independent variables to estimate farmland values. They concluded that land value is a function of site characteristics.

The majority of hedonic price analysis studies reports the use of a specific functional form. Pace (1993) applied the ordinary least squares and nonparametric kernel estimators for a hedonic price analysis using two different data sets. One data set used a hedonic model to explain variability in house rents. The second data set used hedonic models to study the effects of pollution on housing prices. Results from this work showed that, for both data sets, the nonparametric estimator worked better than the ordinary least squares estimator in ex-sample predictive error. The nonparametric estimates presented less variability in coefficients in ex-sample goodness of fit with respect to changes in data quality and in specification.

In a later study, Pace (1995) developed a hedonic model to estimate selling price of houses using a different data set. In this paper, the author used ordinary least squares, nonparametric, and semiparametric estimators. Specifically, the author used the kernel nonparametric regression and the semiparametric index model estimators. In general, the semiparametric estimator displayed the best performance, followed by the nonparametric and the ordinary least squares estimators, respectively.

Kennedy and Vandeveer used the hedonic approach and ordinary least square procedures to analyze rural land values in Louisiana. They concluded that several physical and locational tract characteristics, such as size of tract, percent of cropland, value of improvements, the distance to city, paved road access, rice base acreage, and soil variables, had positive influences on the price of land.

Hedonic Models Using Spatial Statistics

Hedonic regression estimated with cross sectional data is particularly prone to spatial autocorrelation. Proximal observations should have closely related error terms and the strength of this relationship should diminish as the distance between observations increases. Dubin estimated the covariance matrix of the error terms using maximum likelihood procedures. The purpose of estimating a covariance matrix of the error terms is to use the information to obtain efficient estimates of the regression coefficients and unbiased estimates of the standard errors. The study confirmed that using ordinary least squares coefficients and estimates of standard errors can lead to mistaken inference in the presence of spatial autocorrelation.

Hardie et al. estimated county level farmland and residential housing values as a function of farm returns, developed land values, household incomes, population densities, and location using spatial econometric analysis. They found the presence of spatial error autocorrelation indicating that neighboring counties have farmland values that are positively correlated for reasons that were not captured by the explanatory variables.

Dubin et al. described how spatial techniques can be used to improve the accuracy of market value estimates obtained using multiple regression analysis. They stated that apartment property rents and (unit) values are likely to be spatially autocorrelated for the same reasons house prices are spatially autocorrelated. The authors estimated ordinary least squares, spatial lag, spatial error, mixed regressive spatially autoregressive models, and a geo-statistical model based on a Gaussian correlogram. They constructed data through simulation procedures so that the selling price of a house is a function only of square feet of living area and location. By using likelihood ratio tests, the authors showed that using spatial information into the estimation procedure allowed for more accurate estimation of coefficients.

Vandeveer et al. measured the effect of location and economic development on Louisiana rural land values. Hedonic models of eight rural land markets were estimated using spatial econometric procedures. For all eight models, statistical tests indicated the presence of spatial autocorrelation in the data. The authors concluded that spatial econometric models fit the data better than ordinary least squares models.

Summary

This chapter outlined the relevant theory that provides the basis for explaining land values. Differences in location, economic development, physical land characteristics, and non-farm attributes among tracts affect land rents and land values. These characteristics along with hedonic pricing models provide a means for measuring and explaining variations in rural land values. Specifically, hedonic models provide a means for estimation of the implicit price of a tract of land based on the various characteristics that affect rural land values.

Traditional econometric procedures have been used to estimate hedonic models. However, recent studies have shown that these models provide biased and inefficient estimates, if spatial autocorrelation is present in the data. Advances in computer and geographical information systems technologies allow the testing for spatial autocorrelation in the data and for estimating spatial models, the latter providing more accurate estimates.

CHAPTER 3 . METHODS AND PROCEDURES

Because tracts of rural land are sold as a package with a variety of attributes and because the sale price reflects the value of the package, it is difficult to evaluate the individual components determining the package price. Hedonic regression provides a means for estimating the effects of the various characteristics of rural land in determining rural land value. In some sense, the implicit or hedonic approach is similar to the subjective process followed by a rural land appraiser when attempting to place a market value on a tract of land. The main difference between the appraiser and the implicit approach is that the latter yields objective empirical estimates of the values of a particular tract of land

The objective of this chapter is to describe and outline estimation procedures used in this analysis. The first section of this chapter describes the hedonic model used for this study to empirically estimate land values. The second part includes an explanation of the econometric approach used by the hedonic land models along with the marginal effects derived from the econometric approach. The third part describes the variables used to construct the hedonic land models. The fourth part includes the assumptions of the hedonic regression model along with an explanation of all the tests used to verify the validity of the hedonic model. The last section describes the specific spatial econometric methods utilized in this research.

Economic Hedonic Pricing Model

Hedonic procedures were used to estimate rural land values in Louisiana. Hedonic analysis is a method used for economic modeling, specifically designed to value various characteristics that are bundled in one marketable asset or product. This method is often used to study house sales, since a house is sold as a bundled package of individual characteristics like square footage, proximity to schools, and number of rooms. The importance of this method is that it facilitates the determination of underlying implicit prices that each characteristic contributes in the overall value of the bundle making up a particular good or service. Therefore, hedonic models can be applied to the analysis of rural land value, as rural land also consists of a bundle of various characteristics that contribute to returns in agriculture, including soil properties, climate, location, economic development, eligibility for enrollment in government programs, potential for irrigation, and other factors. There are other characteristics of rural land that are not agricultural in nature but contribute to the value of rural land, such as proximities to urban areas and major highways, recreation sites, type of road access, or a location in a particularly scenic area.

Rosen was the first researcher to develop a hedonic theoretical model that could serve as a basis for empirical techniques. The model considers the interaction of consumers and the producers of a differentiated product. The hedonic model is specified as (Rosen, Xu et al.):

$$P(z) = P(z_1, z_2, \ldots, z_n) \tag{3.1}$$

where P is the per acre sale price of a tract of land and z_i measures the amount of the ith qualitative characteristic related to the land parcel and other relevant market factors.

Econometric Formulation of the Hedonic Land Model

The econometric formulation for this study is presented as the following transcendental function (Chicoine):

$$\text{Price} = \beta_0 Z_1^{\beta_1} \exp\left[\sum_{i=1}^{m} \alpha_i X_i + \sum_{j=1}^{n} \gamma_j D_j + \varepsilon\right] \tag{3.2}$$

where Price is the per acre price of land, Z_1 is the size of the tract in acres, m is the number of additional continuous variables (X_i), n is the number of discrete (dummy) variables (D_j), and ε is a random disturbance term. Given that the price per acre of land is hypothesized to decline as the size of tract increases, but at a decreasing rate. Nonlinearities were incorporated for Z_1 by taking the natural logarithm of both sides of equation 3.2:

$$\ln\text{Price} = \ln\beta_0 + \beta_1\ln Z_1 + \sum_{i=1}^{m}\alpha_i X_i + \sum_{j=1}^{n}\gamma_j D_j + \varepsilon \tag{3.3}$$

Consequently, the beta parameter for the natural log of size is hypothesized to be negative, even though it can take any sign.

<u>Implicit Prices of Rural Land Characteristics</u>

Hedonic analysis helps to identify and measure the effects that various factors have on per acre rural land values. The effects that all factors have in each market can be estimated by marginal implicit prices computed from submarket hedonic models. The implicit marginal price of each characteristic is an estimate of change in per acre price attributed to a one-unit change in that characteristic. For the continuous variables represented in equation 3.3, the partial derivatives, which are the marginal prices, are given by the following:

$$\begin{aligned} \text{IMPZ}_{1,t} &= \frac{\partial P_t}{\partial Z_{1,t}} = \left[\frac{\beta_1}{Z_{1,t}}\right] \times P_t \\ \text{IMPX}_{1,t} &= \frac{\partial P_t}{\partial X_{1,t}} = \left[\beta_1\right] \times P_t \end{aligned} \tag{3.4}$$

where, P is the per acre price of land (in this study it represents the mean price), Z is the size of the tract in acres, and X represents the continuous variables. The subscript t indicates that there are implicit prices associated with each transaction. To estimate the marginal implicit price at the mean price and mean level of the characteristic over all observations, the mean value of each variable must be substituted into equation 3.4.

In this study, travel time variables were estimated as an inverse relationship with respect to land values. Therefore, the MIP for the reciprocal of the variable is given by:

$$\frac{\partial \text{Price}}{\partial \text{INVT}} = \text{MIPINVT}_{1,t} = \left[\frac{\beta_{\text{INVT}}}{(\text{Mean INVT})^2}\right] \times P_t \tag{3.5}$$

The derivative for discrete variables is given in semi-logarithmic equations using the formula described by Kennedy (1981):

$$\text{IMPD}_j = \left(e^{\left[c_j - \frac{1}{2}V(c_j)\right]} - 1\right) \times P_t \tag{3.6}$$

where c_j is the estimated coefficient of the discrete variable parameter, $V(c_j)$[6] is the variance of c_j, and mean price is the mean price per acre over all of the observations used in the model. Using the variance of the estimated coefficient can lead to less bias in the estimate when $V(c_j)$ is substantial.

Variables Used in the Hedonic Model

For this study, rural land is defined as all land outside the major metropolitan statistical areas in Louisiana, ten acres or more in tract size, and included attachments to the surface, such as buildings and other improvements. Sale price per acre is the dependent variable used in this study. Factors hypothesized to influence rural land values are presented in Table 3.1. Both discrete and continuous variables are presented in Table 3.1. Continuous variables are quantitative in nature while discrete variables are qualitative. Qualitative variables represent the presence or absence of a condition or characteristic.

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[6] The variance of c_j is estimated by squaring the standard error of c_j obtained from the spatial regression model.

Table 3.1. Variables used in Louisiana hedonic pricing models.

Symbol	Variable[a]	Expected Sign
Continuous Variables		
LNPRICE	Natural log of per acre price of land	
LNSIZE	Natural log of per acre size of land	(-)
CROP	Percentage of cropland in tract	(+)
PASTURE	Percentage of pastureland in tract	(+)
TIMBER	Percentage of timberland in tract	(+,-)
TIME	Month of sale	(+)
VALUE	Value of improvements ($)	(+)
DNT	Distance to nearest town (miles)	(-)
TNT	Time to nearest town (hours)	(-)
INVTC	Inverse of time to nearest city (hours)	(+)
INVTT	Inverse of time to nearest town (hours)	(+)
Binary Variables		
ORLEANS	Intercept dummy for Orleans (St. Tammany) Parish	(+)
CALCASIEU	Intercept dummy for Calcasieu Parish	(+)
PR	Paved road access	(+)
RPRES	Reason for purchase residential	(+)
RPCOM	Reason for purchase commercial	(+)
RPINV	Reason for purchase investment	(+)
RPREC	Reason for purchase recreational	(-)
RPF	Reason for purchase farm	(-)
RESINF	Residential influence	(+)
COMINF	Commercial influence	(+)
HWYINF	Highway influence	(+)
FLINF	Flood influence	(-)
CB	Cotton base	(+)
Binary Soil Variables[b]		
S5	Western Pleistocene Terraces-terraces	(+)
S6	Western Tertiary Upland-upland	(-)
S19	Subtropical Mississippi Valley Alluvium-natural levees	(+)
Binary Slope Variables		
CALSIZE	Natural log of per acre size slope if located in Calcasieu Parish	(-)
CALTIME	Month of sale slope if located in Calcasieu Parish	(+)

[a]Not all variables were tested for each submarket area. Variables for each region were selected based on agricultural characteristics of the area, and on previous studies (Kennedy 1995; Vandeveer et al.; Breaux; Cuellar)

[b] The complete list of soil variables tested for all models is presented in Appendix Table A1.

Continuous Variables

Several authors have included size of tract as an explanatory variable (Downing and Gamble; Elad et al.; Palmquist and Danielson; Xu et al., Vandeveer et al. Size of tract (LNSIZE) is expected to have a negative effect on per acre rural land values. This means that larger sized tracts are expected to sell less per acre than smaller sized tracts. This is because fewer buyers compete in markets for larger tracts; whereas, many buyers compete in markets for smaller tracts. Previous research suggests that this effect is nonlinear (Chicoine, Hushak and Sadr; Sandrey et al.; Shonkwiler and Reynolds), and that is why it is entered in a nonlinear form in the hedonic model (equation 3.3). The proportion of land in a tract devoted to agriculture (CROP) is expected to have a positive influence on per acre land values. Cultivated land may be priced at a premium because it is expected to generate income in the future. Similarly, pastureland represents an intensive use of land, therefore, percent of pastureland (PASTURE) in the tract may also add to the value of rural land.

The impact of percent of timberland (TIMBER) on rural land values is expected to depend on the nature of sale tracts in the area. Merchantable and premerchantable timber is expected to have a positive impact, whereas cutover timber land is expected to have a negative influence on per acre value.

The time (TIME) variable is included in the analysis to measure general upward movements in price and other expectations in rural land values. Dunford et al. use the time variable to explain rural land appreciation and growth. TIME is measured by numbering months consecutively beginning with January, 1993 (month 1) and finishing with July, 2002 (month 114).

Improvements, such as existing houses, barns, fences, and improvements made to or on the land (such as improved pasture), are expected to have a positive impact on per acre land values. The VALUE variable presented in Table 3.1 includes the total value of house, barns, fences, timber, seedlings, and irrigation equipment associated with each sale tract. Improvements generally make operations on real estate more efficient and therefore add to income stream.

Because of the general difficulties in measuring the effect of location on per acre value and because of the variability of this effect between different areas of the state, several variables are included in the analysis. For locational variables including travel time, location theory generally suggests an inverse relationship between distance to markets and per acre selling prices. Distance to nearest town (DNT), and travel time to nearest town (TNT) were computed using the Street Atlas USA computer software, which allows for a better estimation of the actual distance from one point to another (not a straight line). In this study, distances and travel time to the nearest town were calculated using parish seats. GIS procedures were used for defining the closest city to each sale point using concentric circles as presented in Figure 3.1. The center of each circle corresponds to a metropolitan statistical area. Therefore, submarkets could have one or more closest cities. Appendix Table A2 shows the towns and cities with their respective location used in this study. As an alternative measure of location, travel time to the nearest city and town influences were introduced as reciprocal explanatory variables in the hedonic models. These variables are the inverse of time to nearest city (INVTC), and the inverse of time to nearest town (INVTT), which are expected to have a positive sign.

<u>Binary Variables</u>

Binary variables are included to measure the effect of economic development, the effect of different soils, and the effect of structural differences in markets on per acre rural land values. The location of a tract in a metropolitan statistical area is expected to be

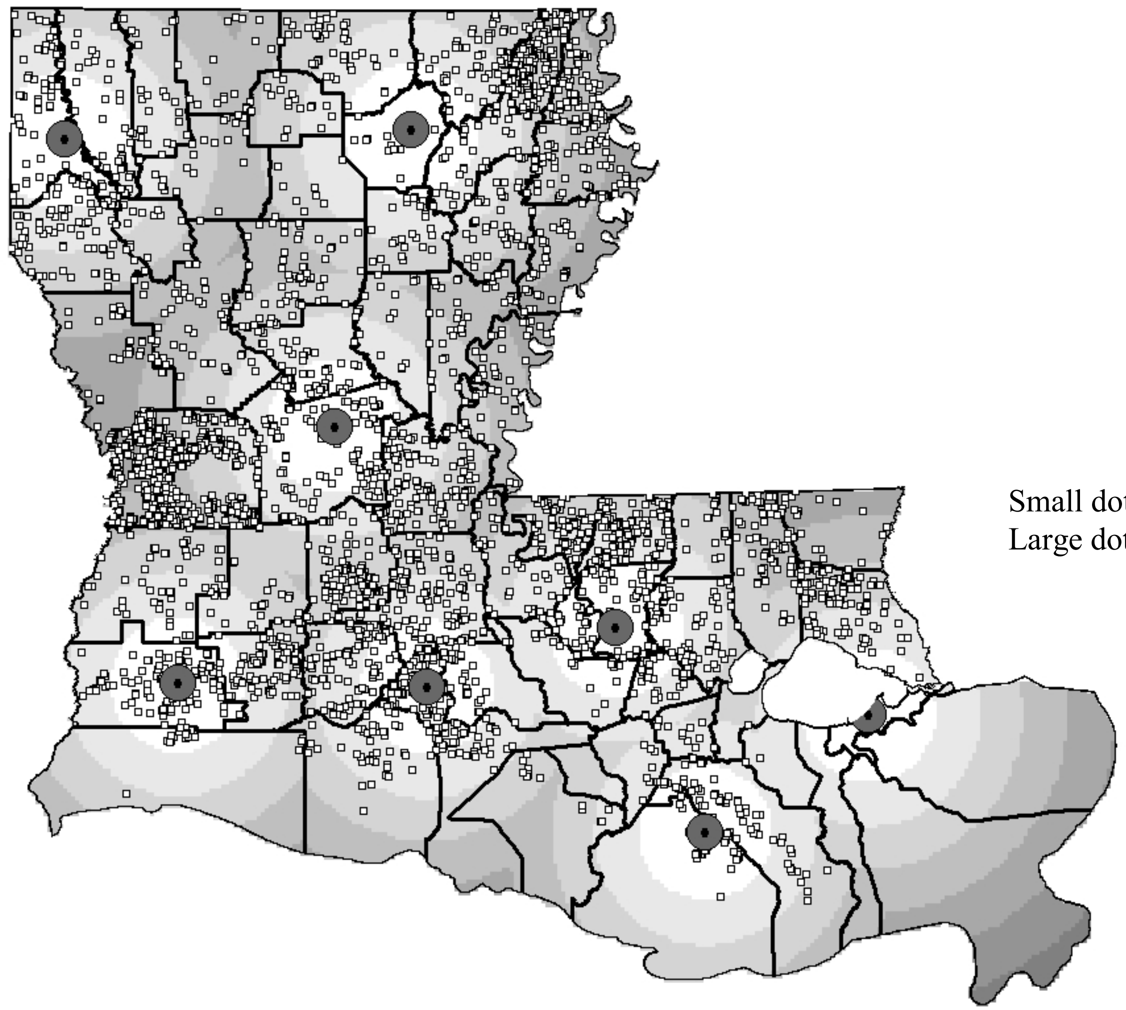

Figure 3.1. Estimation of nearest cities for calculating distance and travel time variables using GIS procedures.

influenced by economic development, and therefore, have a positive impact on per acre land value. Therefore, ORLEANS and CALCASIEU are intercept dummy variables if a tract is located in Calcasieu or St. Tammany parishes, respectively that are expected to positively influence rural land value. Paved road (PR) access is expected to have a positive influence on rural land values and is expected to reflect development potential and accessibility. Reason for purchase residential (RPRES), commercial (RPCOM), and investment (RPINV) are expected to have a positive influence on per acre rural land value. Residential, commercial and investment properties are expected to produce higher rents. Reason for purchase recreational (RPREC) is hypothesized to have a negative relationship with per acre land values because much of the data in this study represent marginal marshland and upland well suited for hunting, trapping, and other outdoor uses. Reason for purchase farm (RPF) is expected to have a negative impact on rural land values because farm properties are expected to produce lower rents when compared to residential or commercial properties. Residential (RESINF) and commercial (COMINF) influences are expected to have a positive impact in per acre rural land values. Potential for residential and commercial development is expected to produce higher rents. Similarly, highway influence (HWYINF) is expected to affect per acre rural land values positively because of the potential for land uses a highway could bring. Flood influence (FLINF) is expected to restrict the use of land and hence have a depressing effect on value. Cotton base (CB) indicates the presence of government program base acres and is hypothesized to be positive because of potential income through government program payments.

The second set of binary variables refers to soil type where tracts are located. In this study, types of soils were assigned by geo-referencing the location of reported sales using

Louisiana GIS CD, ArcView and ArcInfo computer software. In Louisiana, there are a total of 31 types of soils delineated by Pannagl (Appendix Table A1) that were tested for level of significance. However, only soil types that statistically influenced rural land values are included in this section. S5 represents the Western Pleistocene Terraces-terraces soils that are, predominately, the Luka series soils. Luka series are deep, moderately well drained and permeable soils, mostly used for agricultural purposes. Therefore, they are expected to have a positive statistical influence on per acre rural land values. S6 represents the Western Pleistocene Terraces–floodplains soils. Guyton soil series are the predominant soils that consist of deep, poorly drained, slowly permeable soils not suitable for agriculture. Therefore, a negative impact on per acre rural land values is expected for tracts located in these soils. Subtropical Mississippi Valley Alluvium-natural levees soils (S19) are probably part of the Concienne series that have dark grayish brown silt loam surface. Natural levees are usually fertile soils, farming is the most common land use, and they are expected to have a positive influence on per acre rural land values.

The last group of binary slope variables is for the Southwest Area. Dummy variables were included to estimate the hypothesized difference in the variation of the rural land values between Calcasieu Parish and the rest of the study area because of the different structural form. To model this difference, two slope variables were included in the models. Calcasieu natural log of size (CALNSIZE) and Calcasieu month of sale (CALTIME) are expected to have a negative and positive influence, respectively, on per acre rural land values.

Model Assumptions

Hedonic rural land value models are estimated using econometric procedures. For the model to provide unbiased and consistent estimates, the following assumptions for the error term must hold:

1. the random error has an expected value of zero (there is no systematic misspecification or bias in the population regression equation)

    $$E[\varepsilon_i] = 0 \text{ for all } i$$

2. the random error terms are uncorrelated

    $$E[\varepsilon_i \varepsilon_j] = 0 \text{ for all } i \neq j$$

3. the random error terms have a constant variance (homoskedastic)

    $$E[\varepsilon_i^2] = \sigma^2 \text{ for all } i$$

4. the random error follows a normal distribution

    $$\varepsilon_i \sim N(0,\sigma^2)$$

Statistical tests were used to detect the presence of multicollinearity, heteroskedasticity, normality of the errors, serial autocorrelation, and spatial dependence in the data. Multicollinearity refers to the existence of general interrelationships among the set of explanatory variables included in the regression specification. This problem can occur when too many variables are added to the model and some of them are correlated. Consequently, the estimates will have very large estimated variances, resulting in nonsignificant coefficients for the estimates. The test suggested by Anselin (1995) in SpaceStat is the condition number. As a rule of thumb, values of the condition number larger than 20 or 30 suggest the presence of autocorrelation.

Normal error distributions are important in model estimation because a number of regression diagnostic tests are based on the normality assumption. However, because errors cannot be observed, the tests for non-normality are computed from the regression residuals. The Kiefer and Salmon test (Anselin 1995) was used to test for normality in this study. This is an asymptotic test that follows a χ^2 distribution with two degrees of freedom.

Additionally, normality of the errors was tested using the normal quantile-quantile plots using SAS statistical software.

Homoskedasticity of the error term is assumed in econometric model estimation. Heteroskedasticity exists when a random regression error does not have a constant variance over all observations. When data are heteroskedastic, the regression parameters are unbiased but inefficient, and the estimates of the variances are biased. Moreover, inferences based on the usual t and F statistics will be misleading. In this study, the Breusch Pagan test, suggested by Anselin (1995), was used to test for heteroskedasticity. The Breusch Pagan test is asymptotic and follows a χ^2 distribution. This test starts from the null hypothesis of homoskedasticity and the alternative hypothesis is that each observation's error term has a different variance.

In this study, the Durbin-Watson test was used to test for serial autocorrelation. Serial autocorrelation is a characteristic of time series data that exhibits a systematic pattern in the errors.

The Lagrange Multiplier (LM) test was used to detect the presence of spatial autocorrelation as suggested by Anselin (1995). The LM test is an asymptotic test that follows a χ^2 distribution with one degree of freedom. Results from the LM test can be used in the selection of the spatial model specification (error or lag). In addition, the presence of a statistically significant spatial autocorrelation coefficient α from Equations 3.9 and 3.11 implies that there is spatial autocorrelation in the model.

Following Anselin (1995), spatial autocorrelation occurs when the dependent variable or error term at each location is correlated with observations for the dependent variable or error term at other locations. This means that for neighboring locations i and j

$$E\left[y_i y_j\right] \neq 0 \tag{3.7}$$

or

$$E\left[\varepsilon_i \varepsilon_j\right] \neq 0 \tag{3.8}$$

where (3.7) is defined as a spatial lag situation. When the dependent variable exhibits spatial autocorrelation, the simultaneous spatial autoregression estimator corrects the usual prediction of the dependent variable, $y = X\beta + \varepsilon$, by using a weighted average of the values on nearby observations, Wy. The following model specifies the spatial lag situation:

$$y = \alpha Wy + X\beta + \varepsilon \tag{3.9}$$

where y is a vector of dependent observations, α is the spatial autoregressive coefficient, Wy is the spatially lagged dependent variable, W is an n by n weight matrix, X is a matrix of explanatory variables, β is the vector of regression coefficients, and ε is a vector of error terms.

The spatial lag situation assumes that the residuals, ε, are independently and normally distributed. These assumptions are the following:

(i) $w_{ii} = 0$ for all i

(ii) $\sum_{j=1}^{n} w_{ij} = 1$ for all i

(iii) $0 \leq \alpha \leq 1$

(iv) $\varepsilon \sim N(0,\sigma^2 I)$

When spatial dependence occurs in the error, as defined in (3.8), a regression specification with a spatial autoregressive error term is used to develop model estimates. The spatial error model is:

$$y = X\beta + \varepsilon \tag{3.10}$$

$$\varepsilon = \alpha W\varepsilon + \xi \tag{3.11}$$

where y is a vector of dependent observations, X is a matrix of explanatory variables, β is a vector of regression coefficients, ε is a vector of error terms, Wε is the spatial lag for error terms, α is the autoregressive coefficient, and ξ is the error term. Again, W is an n by n weighting matrix with zeros on the diagonal. In this spatial autoregressive model, α is restricted to lie within the interval [0,1], and the errors ξ are independently and normally distributed.

Spatial statistical models are estimated using the maximum likelihood approach. Therefore, the extent to which the predicted values match the observed values for the dependent variable (fitness of the model) cannot be measured by R square. There are several criteria to measure goodness of fit under maximum likelihood estimation. One can assume that the model with the highest log likelihood is the one that achieves the best fit. The problem of the log likelihood is that this number increases with the number of explanatory variables added to the model. Therefore, to correct for overfitting, one can use the likelihood ratio test to compare among models to determine which model fits data the best. In this study, log likelihood numbers and the likelihood ratio test were used to select between the ordinary least square and the spatial maximum likelihood models.

Spatial Weight Matrix

According to Anselin and Hudak, the first stage to implement a spatial econometric strategy is the construction and estimation of the weight matrix, given the spatial arrangement of the observations. The nearest neighbor matrix has been suggested by Dubin et al. as a weight matrix used for real estate sales. The nearest neighbor method is a flexible weights matrix that assumes that spatial dependence depends on a decay relationship and the number of neighbors. Specifically, the nearest neighbor weight covariance matrix is matrix that depends upon three parameters; α, the autoregressive parameter; m, the number of neighbors; and rho (ρ), the rate of weight decline, also referred to as the decay parameter.

The conceptual relationship embedded in the nearest neighbor method is illustrated in Figure 3.2. Weight in the vertical axis represents the weight given by ρ to the power of the

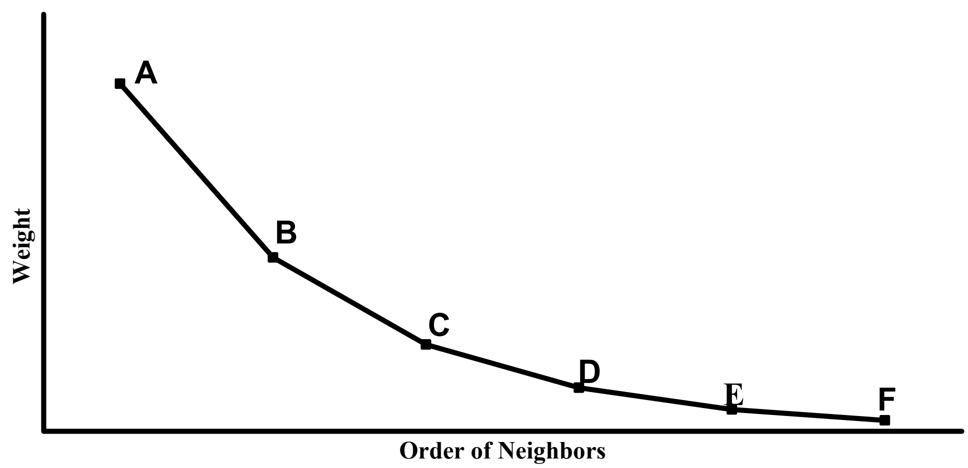

Figure 3.2. Hypothetical decay relationship of decay weights according to the order of neighbors.

order of neighbors. For this example, let's assume that ρ=0.5 and m=6 neighbors (points A through F). Therefore, a ρ of 0.5 indicates that the first neighbor will give half the weight (point A), the second neighbor a quarter of the weight of the first neighbor (point B), and so on. Nearest neighbor point F in Figure 3.2 has little influence in the given observation.

Following Pace (2003), there are several steps in the construction of the nearest neighbor spatial weight matrix. The following is a brief explanation of the steps. The first step consists of using the latitude and longitude of each observation to build a Delaunay triangular matrix. The Delaunay spatial weight matrix can be symmetric or asymmetric and is used to construct the nearest neighbor matrix. The use of symmetric or asymmetric

Delaunay weight matrices depends on the type of nearest neighbor matrix being constructed. When estimating spatial lag models one can use either symmetric or asymmetric nearest neighbor matrix. However, for spatial error models, only the symmetric nearest neighbor spatial matrix can be used. In this study, symmetric nearest neighbor matrices were used to estimate the hedonic models.

In the second step, one computes the nearest neighbors to each observation. In this study, a maximum of thirty neighbors is specified, and the order of Delaunay matrix is four[7].

The third step consists of symmetricizing and weighting the nearest neighbors. The weighting of the nearest neighbors is made by a geometric function that depends on the number of neighbors and the rho parameter. Rho is a decay parameter that indicates the decline of the weight of the jth neighbor with j. To choose the values of rho and number of neighbors (m), a repetitive process involving combination of rho ranging from 0.05 to one at increments of 0.05 with neighbors ranging from one to 30 was conducted. Then, the spatial model with the combination of rho and m that achieved the largest log likelihood number for each specific market was selected.

Spatial Econometric Model

Once the presence of spatial dependence was confirmed to exist, and the spatial weight matrices built for each submarket data, hedonic models were estimated using spatial econometric maximum likelihood regression procedures. The two most frequent methods used by researchers are the spatial lag and the spatial error models, and these were the models used in this study.

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[7] Limits the search for neighbors, neighbors of neighbors, neighbors of neighbors of neighbors, and neighbors of neighbors of neighbors of neighbors

A maximum likelihood procedure was used to conduct spatial model estimation, as suggested by Anselin and Bera; and Dubin et al. This is done by choosing the values of all unknown parameters that maximize the log likelihood function:

$$\ln\ L = \text{constant}\ + \frac{1}{2}\log\left|\tilde{\Omega}^{-1}\right|\ -\ \frac{n}{2}\log\left((Y\ -\ X\tilde{\beta})_{ML}(Y\ -\ X\tilde{\beta}_{ML})\right) \qquad (3.12)$$

where $\tilde{\Omega}$ is the estimated variance-covariance matrix with a nonzero off-diagonal elements. The first term is the log-determinant of the estimated variance-covariance matrix and the second term is the sum-of-squared errors. The formula for the estimates of the regression coefficients is:

$$\tilde{\beta}_{ML} = [X\tilde{\Omega}^{-1}X]X\tilde{\Omega}^{-1}Y \qquad (3.13)$$

Summary

This chapter describes the methods and procedures used to estimate rural land values in Louisiana. The first step is to select the economic model along with factors that influence rural land values. Economic theory suggests the use of hedonic models to estimate rural land values because of the heterogeneous nature of rural land markets. Once the economic model is selected, a transcendental function is used to formulate the econometric representation of the hedonic model and the econometric estimation is conducted. Diagnostic tests are used to verify the validity of the model assumptions. Finally, due to the spatial nature of the data confirmed by statistical tests, spatial econometric procedures are used for hedonic model estimation, and the estimates used for marginal price estimation.

CHAPTER 4 . DATA AND DESCRIPTIVE INFORMATION

This chapter describes procedures that were used in collecting the data. This chapter also summarizes and provides descriptive information on the data base. The first section of this chapter describes how data were collected and organized. In particular, it explains how the survey were developed and how the data were subdivided by regions in Louisiana. The second part presents the descriptive statistics for the first section of the Louisiana Rural Land Market Survey on a statewide basis. In the last part of the chapter, selected statistics of land characteristics, by submarket, are presented and discussed.

Louisiana Rural Land Market Survey

The first objective of this study is concerned with developing procedures for collecting rural real estate land values to update the Louisiana data base. A rural land market survey instrument was used to collect rural land market data. A copy of the instrument is presented in Appendix B. The survey generally is organized to collect rural land values, location and other characteristics of the rural land market.

Rural Land Survey for July 1998 to June 2002 Sale Period

The techniques used in the present study encompass three general steps: 1) selecting the respondents, 2) survey structure and identifying the questions, and 3) using the appropriate techniques for conducting the survey. Given the specific nature of the data required for this study, a statewide listing of individuals with knowledge of Louisiana rural land markets was developed. The listing included 1,054 individuals from commercial banks, the Farm Service Agency, Federal Land Bank and Louisiana Agricultural Credit personnel. In addition, this survey was mailed to members of the Louisiana Real Estate Commission, the Louisiana Chapter of the American Society of Farm Managers and Rural Appraisers and the

Louisiana Realtors Land Institute. The list of surveyed individuals by group, and the source of information, are presented in Table 4.1.

Table 4.1. Selected entities for rural land market survey and source of information, July 1, 1998 to June 30, 2002 sale period.

Entity	Source of information[a]
Commercial Banks	Louisiana Financial Directory, Louisiana Bankers Association 5555 Bankers Avenue, Baton Rouge, LA 70808 or www.lba.org
Federal Land Banks	www.louisianalandbank.com/locations.htm
Farm Service Agency	www.fsa.usda.gov/la/
Louisiana Ag Credit (Production Credit Ass.)	www.Louisianaagcredit.com
General Appraisers	Louisiana Real Estate Commission, 9071 Interline Avenue, Baton Rouge, LA 70809
Residential Appraisers	Louisiana Real Estate Commission, 9071 Interline Avenue, Baton Rouge, LA 70809
Rural Appraisers	Dr. Kenneth Paxton, akpaxt@lsu.edu
Rural Realtors	Dr. Steven A. Henning, shenning@agctr.lsu.edu

[a] Internet sources as August 2003.

The questionnaire used in this study consists of three sections[8]. The survey was constructed to facilitate the reporting of detailed information on actual rural real estate sales in Louisiana and to record subjective information based on the respondent's knowledge of the local market. The first section of the survey was designed to collect detailed information on actual sales of rural real estate that occurred between July 1998 and June 2002. Respondents were asked to provide as much information as possible on actual rural tract sales during the survey period, and not to include sales involving close relatives. The size of the tract was limited to ten acres or more in size, and outside the city limits of major metropolitan areas. The second and third sections of the survey were designed to collect subjective information. The respondents were asked for estimates based on their knowledge of the local land market. The second section of the questionnaire was also designed to obtain

[8] Similar to the sections used by Kennedy (1995) in his dissertation.

typical land rental arrangements for a range of crops grown in the respondent's area. The purpose of the last section of the survey was to obtain subjective information on estimated values of different types of land throughout the state as well as a respondent's expected land market activity over the next year. The second and third part of the survey will be used for future research and results will not be included in the present study.

This study generally followed the procedures outlined by Dillman in conducting the mail survey[9]. The method used in this study includes mailing the survey (11/25/2002), sending a postcard reminder fourteen days after the initial mailing (12/09/2002), sending a duplicate questionnaire approximately a month after mailing the survey (01/02/2003), and a second postcard reminder ten days after the second mailing to non-respondents (01/15/2003). Respondents were also provided with the opportunity to respond to the survey electronically. The survey was constructed in a spreadsheet format and was available in the departmental web page. It is expected that this type of survey will be used more often in the future.

Data

Information for this study includes sales that were collected for the time period January 1993 to June 30, 1998, and data collected as a part of this study for the period July 1, 1998 to June 30, 2002. For the latter period, response rates of the surveyed groups are summarized in Table 4.2. A total of 280 of the 1,054 individuals surveyed responded (a 27 percent rate). However, a total of 1,041 useful land tract observations were recorded. Rate of responses varied among the different groups, with many respondents providing multiple sales for the study. Distribution of annual responses collected as part of this study is

[9] Copies of letters of introduction and postcards can be found in Appendix B.

presented in Figure 4.1. Except for 1998, responses were evenly distributed throughout the years for the July 1, 1998 to June 30, 2002 period.

Table 4.2. Response frequency by survey group, 2002 Louisiana Rural Land Market Survey, July 1, 1998 to June 30, 2002.

Survey Group	Number Surveyed	Number of Respondents	Number of Sales Reported
Commercial Banks	150	49	25
Federal Land Banks	9	6	148
Farm Service Agency	44	22	101
Louisiana Ag Credit	17	3	0
General Appraisers	265	69	469
Residential Appraisers	547	123	128
Rural Appraisers	25	3	22
Rural Realtors	17	5	248
Total	**1054**	**280**	**1141**

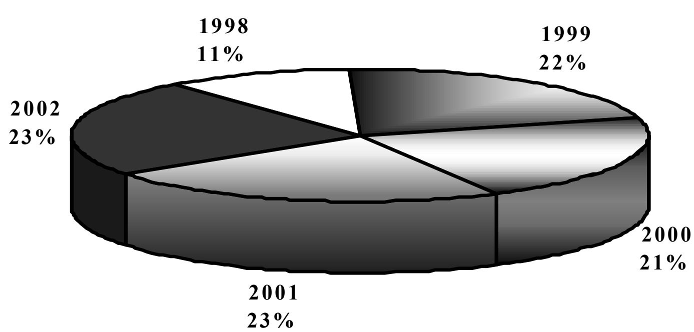

Figure 4.1. Distribution of Louisiana rural sale responses, by year, for the July 1, 1998 to June 30, 2002 period.

Responses, by price range, for the 1993-2002 period are plotted in Figure 4.2. The data were spatially plotted based on the legal description that includes township, range, and section information of each tract, using ARC/View software. The plot of the data (Figure 4.2) suggests that rural land sales are widely dispersed throughout the state, and that sales with higher values cluster near metropolitan areas.

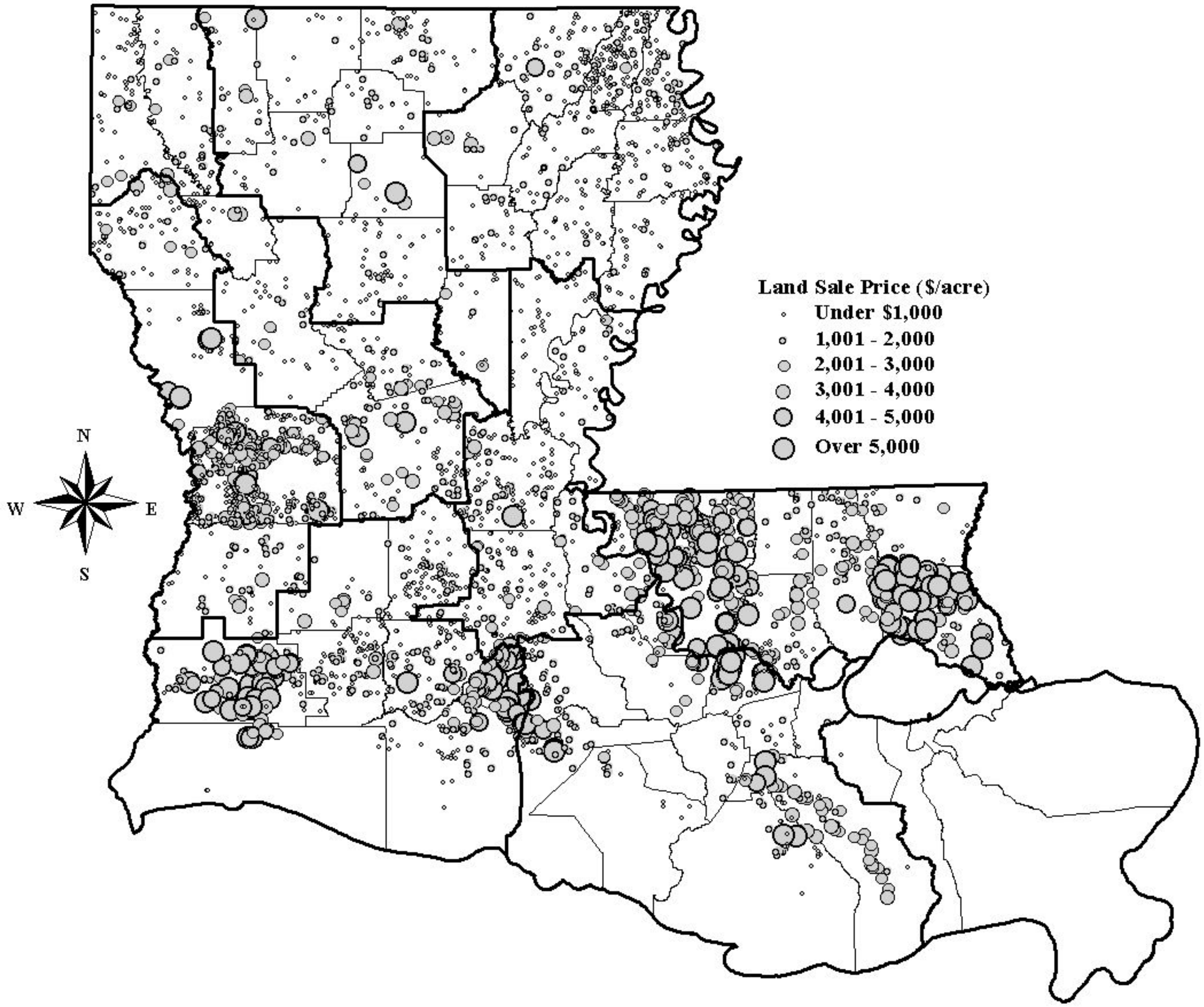

Figure 4.2. Location of reported sales and price, Louisiana Rural Land Market Survey, January 1, 1993 to June 30, 2002.

Organization of the Data by Submarket Area

When conducting a spatial analysis for a large area, it is important to identify homogeneous rural land submarkets within the area, so data can be organized for further analysis. Rural land submarket areas for this study are defined in Figure 4.3. The nine rural land submarket areas were estimated in a previous study (Kennedy and Vandeveer) using multivariate statistical techniques and multiple physical and socio-economic variables. Figure 4.3 shows the nine Louisiana rural land submarket areas. However, because only two observations were available for the Metro New Orleans Area, this study focuses on the remaining eight submarkets: Western Area, Red River Area, North Central Area, North Delta Area, Southwest Area, Central Delta Area, Southeast Area, and Sugarcane Area.

Descriptive Information for the State of Louisiana

Data for this study were collected from section I of the survey (Appendix B). A total of 3,542 observations (2,501 collected for the time period January 1, 1993 to June 30, 1998, and 1,041 collected for the time period July 1, 1998 to June 30, 2002) were used in this study. The first five questions of the survey were used to determine the time of sale and the location of the tract. Time of sale is used to determine the month of sale, and serves as a variable that accounts for inflation. Location of the tract is necessary to construct the spatial weight matrix, and in estimating some attributes of the land such as type of soil, distance variables, and proximity of tracts to metropolitan statistical areas (MSAs) using GIS procedures.

As part of the survey, respondents were asked to indicate the sale price and size of tract. They were also asked to specify what proportion of the tract of land was in crops, pasture and timber along with the primary commodities produced on the tract of land at the

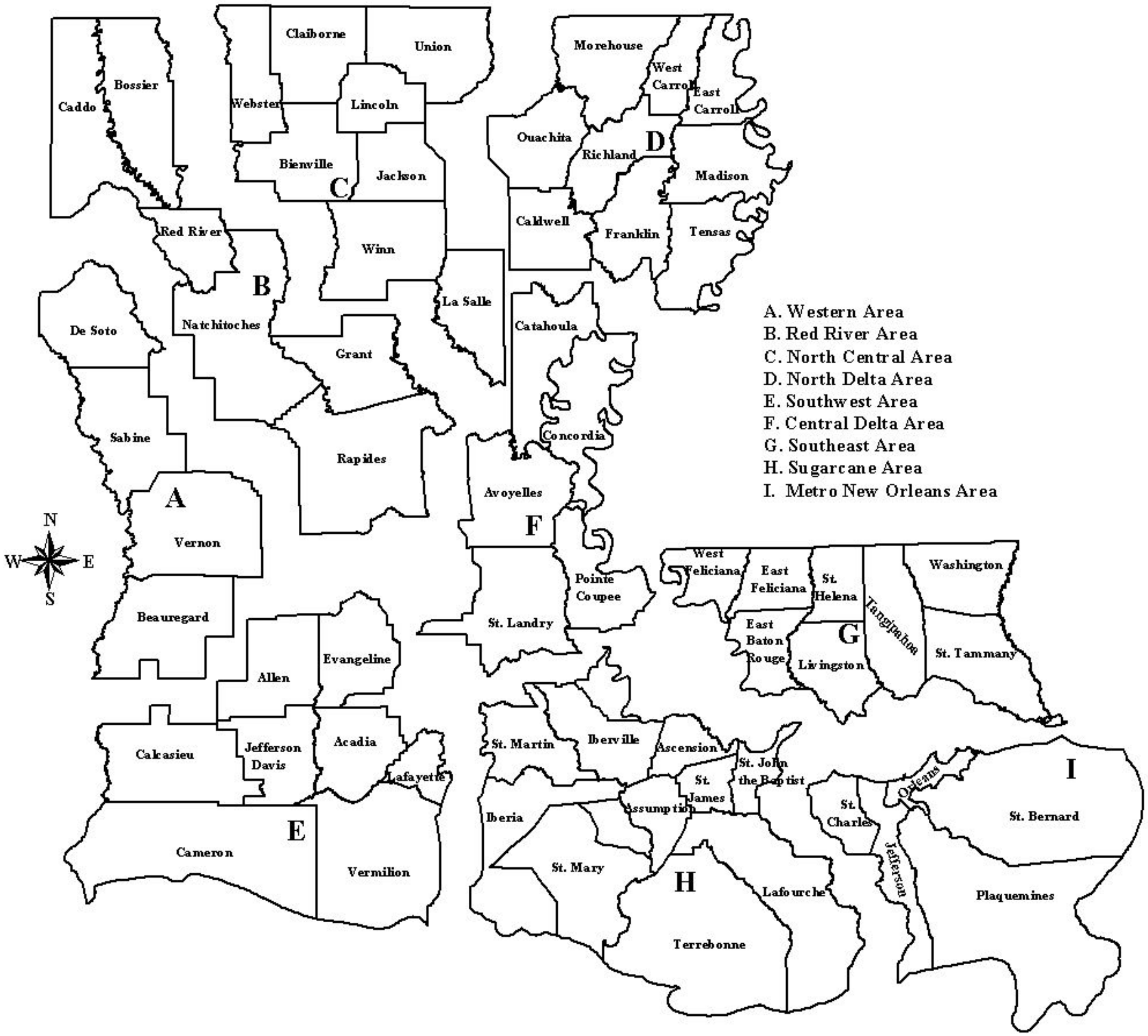

Figure 4.3. Louisiana rural land submarkets, used in the present study (Kennedy et al.).

time of sale. Mean and median rural real estate land values, median and mean tract size, as well as other selected information for the state are reported in Table 4.3. Percentages of land used in the production of crops, pasture and timber, along with the mean and median price and size of the tract associated with the proportions are also presented in Table 4.3. The twelve primary commodities reported by respondents, for the whole state, along with the mean price and sizes of the tract associated with each enterprise are also reported in Table 4.3.

Statewide results indicate that rural land values ranged from \$200 to \$20,350 per acre. The median price per acre was estimated at \$962 while the mean value at \$1,448. These results indicate a substantial variability in per acre real estate values in Louisiana for the surveyed period. Mean size of tract was estimated at 162 acres with a median of 59 acres, ranging from 10 to 6,516 acres.

Respondents indicated that 2,044 of the 3,542 tracts sold had a portion of land dedicated to the production of crops, timber, or pasture. The sample estimates indicated that the mean size of tract associated with these types of land use was 216 acres. The mean proportion of cropland, pastureland and timberland were estimated at 41, 22 and 31 percent, respectively.

Mean land values for tracts used in the production of primary crop commodities were estimated to range from \$749 per acre for soybeans to \$1,547 per acre for sugarcane. Mean land value for tracts in which beef is the primarily produced commodity were estimated at \$1,338 per acre and a mean tract size of 127 acres. Similarly, mean land values for timberland commodities were estimated to ranged from \$775 per acre for cutover pine to

Table 4.3. Mean land values and other characteristics, state summary, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
State summary	3,542					
Price per acre ($)		200	20,350	962	1,448.49	1,615
Size (acres)		10	6,516	59	161.90	366.74
Percent of land in crop, pasture and timber	2,044					
Price per acre ($)		200	16,000	894	1,236.57	1,186.23
Size (acres)		10	6,516	82	215.98	441.94
Percent cropland				0	40.54	44.76
Percent pastureland				0	21.85	36.96
Percent timberland				0	30.92	42.01
Sales with cotton as primary commodity	314					
Price per acre ($)		313	3,500	805.5	866.79	373.21
Size (acres)		10	2429	161.5	306.53	379.81
Percent cropland				92	86.39	17.05
Government program base acres		0	1,142	50	103.69	156.44
Sales with soybeans as primary commodity	182					
Price per acre ($)		250	2,800	634.5	748.54	406
Size (acres)		10	5,889	92	225.15	534.34
Percent cropland				92	86.28	19.09
Sales with sugar cane as primary commodity	137					
Price per acre ($)		314	6,500	1,328	1,546.72	957.48
Size (acres)		10	2,959	91	276.90	439.63
Percent cropland				88	72.23	34
Sales with rice as primary commodity	234					
Price per acre ($)		250	3,500	869	939.84	399.22
Size (acres)		13	6,516	160	367.49	750.20
Percent cropland				92	81.81	30.54
Government program base acres		0	3,000	36.5	111.60	264.51
Sales with vegetables as primary commodity	7					
Price per acre ($)		400	1,000	713	686.86	247.30
Size (acres)		30	188	80	96.29	62.33
Percent cropland				99	92.71	11.74
Sales with beef as primary commodity	265					
Price per acre ($)		215	10,110	964	1,337.60	1,273.12

(table continued)

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Size (acres)		10	2,405	80	127.11	190.50
Percent pastureland		0	100	90	79.88	26
Sales with cutover pine as primary commodity	64					
Price per acre ($)		200	4,500	600	775.14	618.36
Size (acres)		10	1,180	60	128.83	204.6
Percent timberland				75.5	53.5	47.41
Sales with premerchantable pine timber as primary commodity	90					
Price per acre ($)		250	4,500	775	989.59	744.85
Size (acres)		10	842	55.5	81.18	106.54
Percent timberland				100	75.92	40.82
Sales with merchantable pine timber as primary commodity	100					
Price per acre ($)		300	6,949	1,508	1,740.69	1,143.49
Size (acres)		10	1,107	52	93.38	154.22
Percent timberland				100	93.35	16.91
Sales with cutover hardwood as primary commodity	23					
Price per acre ($)		238	5,500	550	863.74	1,084.75
Size (acres)		25	875	120	202.65	217.56
Percent timberland				100	73.39	40.19
Sales with premerchantable hardwood timber as primary commodity	18					
Price per acre ($)		250	4,500	850	1,351.5	1,185.43
Size (acres)		15	2,291	77.5	286.67	539.90
Percent timberland				100	74.11	39.36
Sales with merchantable hardwood timber as primary commodity	61					
Price per acre ($)		313	6,027	967	1,515.64	1,257.51
Size (acres)		20	3,910	123	284.95	562.84
Percent timberland				100	91.54	19

$1,741 for merchantable pine timber, while mean acreage was estimated to vary from 81 acres for premerchantable pine timber to 287 acres for premerchantable hardwood timber.

Locational and economic development factors are also expected to affect land use and affect highest and best use of land. Multiple uses of land and selection of highest and best use of land are expected to increase bidding activity in rural land markets and hence influence land values in affected areas. In this survey, respondents were asked about the highest and best use of the tract of land. Distribution of the highest and best use of land reported by respondents in the survey is presented in Figure 4.4.

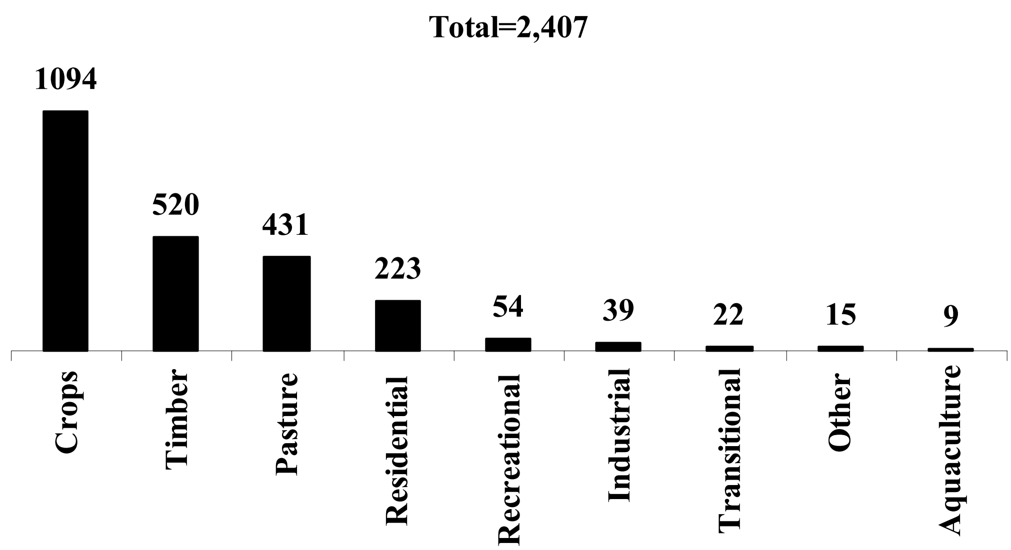

Figure 4.4. Highest and best use of land, Louisiana Rural Land Market Survey, January 1, 1993 to June 30, 2002.

Respondents indicated that 45 percent of the sale tracts were cropland, 22 percent timberland and 18 percent pastureland. Nine percent of the respondents reported residential as the highest and best land use, and less than three percent was for recreational, industrial/ commercial, or aquaculture purposes.

The presence of paved road access is expected to have a positive influence on rural land values because it reflects development potential and accessibility. Distribution of the number of respondents, by submarket area, who reported sales of tracts with paved road access, is presented in Figure 4.5. Southeast and Southwest areas are reported to have the majority of tracts of land with paved road accessibility, followed by North Central, Central Delta, Red River and Sugarcane areas. Respondents from the North Central and Western areas indicated fewer tracts of land with paved road accessibility.

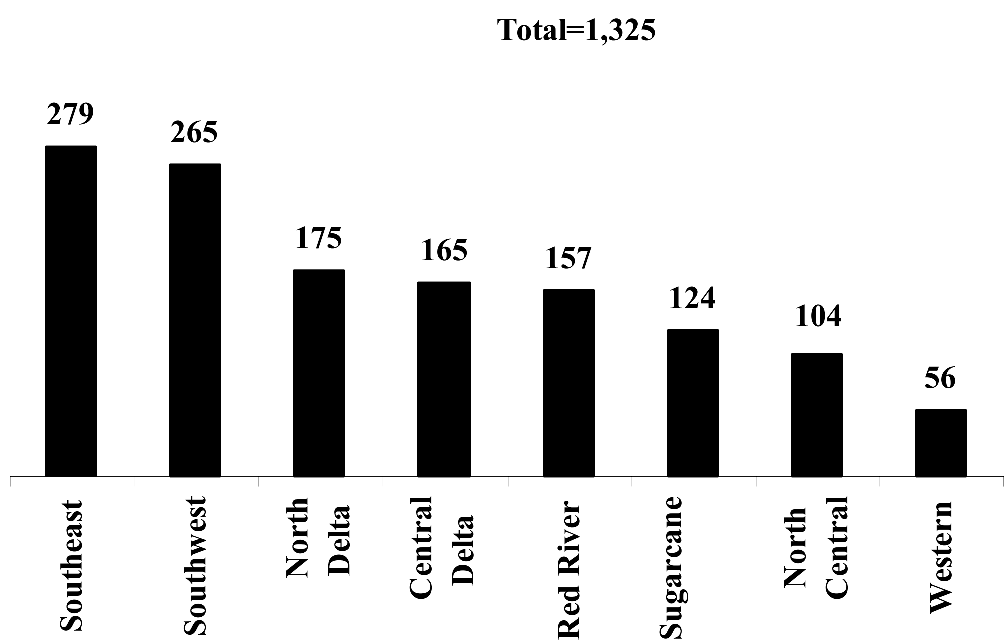

Figure 4.5. Paved road access frequency, Louisiana Rural Land Market Survey, January 1, 1993 to June, 30, 2002.

Respondents were asked to identify the main reason for purchase of each tract. The distribution of frequencies of main reason for purchase from the 1,823 respondents is presented in Figure 4.6. Results indicate that most frequent reasons for purchase are expansion of land holdings (38 percent), investment (27 percent), residential (14 percent),

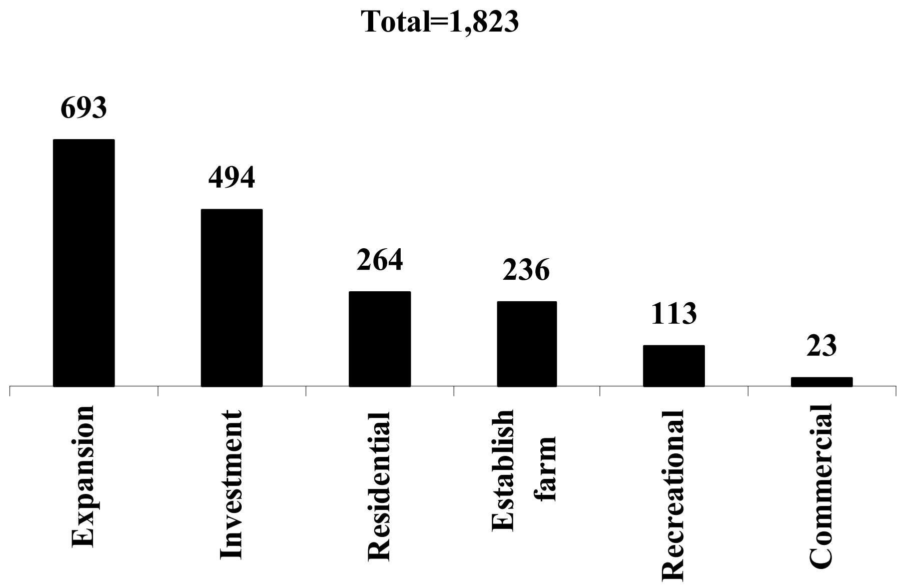

Figure 4.6. Reason for real estate purchase, Louisiana Rural Land Market Survey, January 1, 1993 to June 30, 2002.

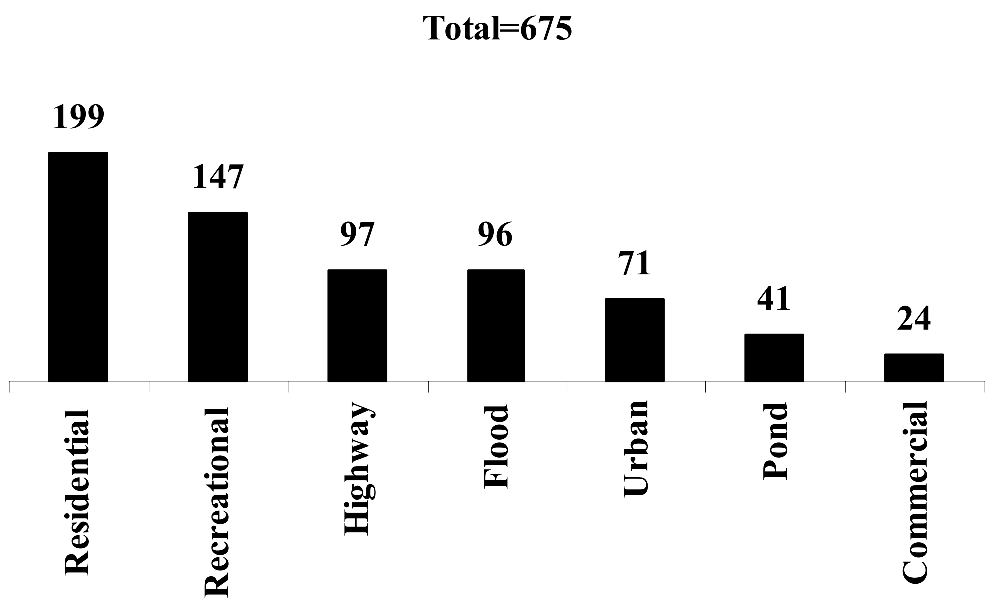

Figure 4.7. Factors influencing real estate values, Louisiana Rural Land Market Survey, January 1, 1993 to June 30, 2002.

establishing a farm (13 percent), and recreational (6 percent). The least frequent reason for purchase is commercial (1 percent).

Respondents of the Louisiana Rural Land Market Survey were also asked to identify other significant influences on land value for each tract of land. The distribution of frequencies from responses is illustrated in Figure 4.7. Respondents indicated the influence for purchasing real estate for 675 tracts. Responses indicated that residential (30 percent) and recreational (22 percent) are the two factors that influence rural lands values the most. Other factors considered to influence rural land vales are the presence of a highway (14 percent), flood (14 percent) and urban development (11 percent). Less frequent influences are the presence of ponds in the tract (6 percent) and the potential for commercial land use (4 percent).

Descriptive Information by Submarket Area

This section summarizes the statistics for price and size for each submarket area. Only sales that reported five or more observations of a particular primary commodity are reported in this section. Information on locational variables is also included in each table.

Western Area (Submarket A)

The Western area is defined here to include De Soto, Sabine, Vernon, and Beauregard parishes (Kennedy 1995). Estimates presented in Table 4.5 summarize selected characteristics for the study area. Estimated mean price of rural land for the nine-year period was $1,088 per acre with a median of $900 per acre. Land values were estimated to vary from $200 to $5,882 per acre, and the standard deviation for price per acre at $789 reflects the wide variability in prices. The mean size of tract was estimated at 57 acres, and size of tracts varied from 10 to 5,052 acres.

Table 4.4. Mean land values and other characteristics, Western Area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Western Area summary	835					
Price per acre ($)		200	5,882	900	1,088.2	788.76
Size (acres)		10	5,052	30	56.97	191.50
Percent of land in crop, pasture and timber	160					
Price per acre ($)		200	3,502	800	917.63	537.69
Size (acres)		10	5,042	57	125.9	415.87
Percent cropland				0	3.37	21.51
Percent pastureland				40	44.24	44.16
Percent timberland				40	48.3	44.80
Sales with beef as primary commodity	35					
Price per acre ($)		313	2,303	800	914.6	444.52
Size (acres)		12	620	70	107.94	128.31
Percent pastureland				95	87.11	17.34
Sales with cutover pine as primary commodity	13					
Price per acre ($)		200	785	487	530.77	172.11
Size (acres)		19	393	44	95.31	104.05
Percent timberland				0	15.38	37.55
Sales with premerchantable pine timber as primary commodity	10					
Price per acre ($)		400	1,125	561	596.3	233.39
Size (acres)		23	156	55	70.5	44.21
Percent timberland				100	86	32.73
Sales with merchantable pine timber as primary commodity	15					
Price per acre ($)		400	2,675	1,250	1,347.6	731.69
Size (acres)		13	160	40	47.4	38.33

(table continued)

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Percent timberland				100	97	9.22
Distance measurements	835					
Time to nearest town (hours)		0.02	1.08	0.48	0.49	0.22
Distance to nearest town (miles)		0.4	54.4	17.5	17.5	8.95
Time to nearest city (hours)		0.25	2.4	1.38	1.35	0.34
Distance to nearest city (miles)		10.8	87.3	56	54.04	12.85

Estimated amounts of land used in the production of crops, timber, and pasture are presented in Table 4.5. Estimates indicated that the mean amount of cropland in this area is three percent, while the mean amount of pastureland is 44 percent, and the mean amount of timberland is 48 percent. Respondents reported beef as the primary commodity produced in this area with a mean land value estimated at $915 per acre and a mean tract size at 108 acres.

Timberland was summarized into three categories in this area. Estimates presented in Table 4.4 suggest that the percentage of timberland dedicated to the production of cutover pine was 15 percent, 86 percent of premerchantable pine timber, and 97 percent of merchantable pine timber. Estimated mean land value for tracts with cutover pine was the lowest at $531 per acre, but the estimated largest mean tract size at 108 acres.

Descriptive statistics for the distance measurements are presented in Table 4.4. Street Atlas USA computer software was used to estimate travel time and distances to nearest city and towns. De Ridder, Leesville, Mansfield, and Many are the parish seats, and Shreveport, Alexandria, and Lake Charles are the cities used in the estimation of distances and travel time. Mean distance to the nearest town and city were estimated at 17 and 54 miles, respectively. Likewise, mean travel time to the nearest town and city were estimated at 0.49 and 1.35 hours, respectively.

Red River Area (Submarket B)

The Red River Area is defined to include Bossier, Caddo, Natchitoches, Grant, Rapides, and Red River parishes. The parishes of Caddo and Rapides include Shreveport and Alexandria metropolitan statistical areas, respectively.

Selected characteristics for the Red River Area are summarized in Table 4.5. The median and the mean per acre values of rural land were estimated at $745 and $960,

Table 4.5. Mean land values and other characteristics, Red River Area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Red River Area summary	319					
Price per acre ($)		200	3,500	745	960.09	685.98
Size (acres)		10	1,904	71	181.38	298.54
Percent of land in crop, pasture and timber	284					
Price per acre ($)		229	3,500	737.5	960.47	691.84
Size (acres)		10	1,904	79	189.90	309.82
Percent cropland				0	24.23	39.78
Percent pastureland				0	17.59	34.4
Percent timberland				87.5	54.51	47.41
Sales with cotton as primary commodity	50					
Price per acre ($)		313	3,500	838	943.86	611.19
Size (acres)		10	1,581	167	359.62	397.92
Percent cropland				94	87.68	15.18
Government program base acres				5.5	68.26	120.44
Sales with soybeans as primary commodity	16					
Price per acre ($)		250	979	475	497.62	191.68
Size (acres)		15	1,736	185.5	346.87	427.91
Percent cropland				91.5	86.75	15.04
Sales with beef as primary commodity	44					
Price per acre ($)		264	2,619	676.5	889.66	615.64
Size (acres)		12	690	88.5	155.64	169.24
Percent pastureland				95.5	81.77	25.55
Sales with cutover pine as primary commodity	12					
Price per acre ($)		250	1,200	400	551.67	335.47
Size (acres)		10	800	92.5	223.83	285.29
Percent timberland				100	80.58	38.81
Sales with premerchantable pine timber as primary commodity	26					
Price per acre ($)		275	3,114	858.5	1,082.15	692.68
Size (acres)		10	220	40	49.58	40.66

(table continued)

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Percent timberland				100	90	29.19
Sales with merchantable pine timber as primary commodity	39					
Price per acre ($)		300	3,317	1,406	1,496.44	873.11
Size (acres)		11	1,107	40	99	217.12
Percent timberland				100	96.54	11.98
Sales with merchantable hardwood timber as primary commodity	6					
Price per acre ($)		469	2,000	633	940.5	619.57
Size (acres)		10	139	43.5	56.5	47.68
Percent timberland				100	100	0
Distance measurements	319					
Time to nearest town (hours)		0.05	1.17	0.52	0.53	0.22
Distance to nearest town (miles)		1.7	48	20.5	20.44	8.89
Time to nearest city (hours)		0.18	1.57	0.67	0.72	0.29
Distance to nearest city (miles)		6.9	77.4	26.1	29.76	14.75

respectively. Prices were estimated to range from \$200 to \$3,500 per acre with a standard deviation of \$686 per acre indicating a large variability in prices. Median and mean tract sizes were estimated to be 71 and 181 acres, respectively.

Results suggest that, on average, the amounts of land dedicated to the production of crops, pasture and timber were 24, 18, and 55, respectively. Cotton, soybeans, beef, cutover pine, premerchantable pine, merchantable pine, and merchantable hardwood timber were the primary commodities reported by respondents. Mean per acre land values involving cotton and soybeans as primary commodities were estimated at \$944 and \$497 per acre, respectively. Mean tract size was estimated at 360 and 347 acres for land producing cotton and soybeans as primary commodities, respectively. Reported mean land value for tracts with beef as primary commodity was estimated at \$890 per acre and the mean tract size at 155 acres.

Land values for tracts involving timber as primary commodity were estimated at \$1,497 per acre for merchantable pine timber, \$1,082 per acre for premerchantable pine timber, and \$940 per acre for merchantable hardwood timber. Tracts of land having cutover pine had the lowest estimated mean land value at \$552 per acre.

Distance to nearest town and city along with corresponding travel time estimates were developed using the Street Atlas computer software. Parish seats used for estimation of distance and travel time to the nearest town are Natchitoches, Alexandria, Bossier City, Colfax, Shreveport, and Coushatta. Shreveport and Alexandria were the cities selected for estimating the travel and distance to the nearest city variables. On average, travel time to the nearest town (0.53 hours) was estimated to be smaller than travel time to the nearest city

(0.72 hours), and mean distance to nearest town (20 miles) was estimated to be smaller than mean distance to nearest city (30 miles).

North Central Area (Submarket C)

The North Central Area is defined to include Bienville, Union, Claiborne, La Salle, Jackson, Webster, Lincoln, and Winn parishes. Descriptive statistics of selected land characteristics for the North Central Area are presented in Table 4.6.

The median and mean land values were estimated at $658 and $797 per acre, respectively. This is the smallest median land value estimated for all submarket areas. Land values were estimated to range from $250 to $3,714 per acre. The estimated mean tract size was 87 acres, the second smallest among all submarket areas.

Of the 213 responses, 169 individuals reported the proportion of land used in the production of crops, timber and pasture. Mean proportions of timberland, pastureland, and cropland were estimated at 60, 34, and 0.30 percent, respectively. The mean price associated with land use was estimated at $851 per acre and the mean tract size was estimated at 96 acres.

Analysis of data suggests that the primary commodities produced in this area are beef, cutover pine, premerchantable pine timber, merchantable pine timber, and merchantable hardwood timber. For tracts of land used in the production of beef, the average value was estimated at $860 per acre, and mean tract size at 123 acres.

Land sales involving cutover pine as primary commodity were estimated to have a mean price of $693 per acre and a mean tract size of 46 acres. The mean price for land with premerchantable pine timber was estimated at $761 per acre and the mean tract size was estimated at 92 acres. The largest estimated mean land value of $1,382 per acre corresponded to tracts of land where pine timber was produced.

Table 4.6. Mean land values and other characteristics, North Central Area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
North Central Area summary	213					
Price per acre ($)		250	3,714	658	797.33	510.66
Size (acres)		10	842	60	87.03	96.41
Percent of land in crop, pasture and timber	169					
Price per acre ($)		250	3,714	730	851.01	257.41
Size (acres)		10	842	63	96.19	105.29
Percent cropland				0	0.30	3.85
Percent pastureland				0	33.67	42.48
Percent timberland				95	59.46	44.93
Sales with beef as primary commodity	48					
Price per acre ($)		424	3,230	728	859.75	493.64
Size (acres)		15	540	93.5	123.46	102.80
Percent pastureland				85	79.06	22.69
Sales with cutover pine as primary commodity	14					
Price per acre ($)		250	1,333	590.5	692.57	337.07
Size (acres)		10	90	40	46.36	27.56
Percent timberland				0	30	46.24
Sales with premerchantable pine timber as primary commodity	30					
Price per acre ($)		250	2,000	683.5	761.17	391.35
Size (acres)		15	842	62	91.63	146.96
Percent timberland				99	64.47	46.77
Sales with merchantable pine timber as primary commodity	14					
Price per acre ($)		475	3,714	1,217	1,382	324.60
Size (acres)		17	160	60	69.86	46.13
Percent timberland				100	87.5	22.34
Sales with merchantable hardwood timber as primary commodity	7					
Price per acre ($)		393	1,520	663	775.86	374.13

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Size (acres)		47	160	80	90.86	35.57
Percent timberland				100	88.57	22.68
Distance measurements	213					
Time to nearest town (hours)		0.03	1.05	0.38	0.40	0.21
Distance to nearest town (miles)		1.3	47	14.1	15.02	8.92
Time to nearest city (hours)		0.5	1.93	1.08	1.10	0.26
Distance to nearest city (miles)		16.2	76.3	46.9	45.86	10.60

Travel time and distance to nearest towns and city estimates were calculated using Street Atlas USA computer software. These estimates are presented in Table 4.6. Arcadia, Farmerville, Homer, Jena, Jonesboro, Minden, Ruston, and Winnfield are the parish seats and Shreveport, Monroe and Alexandria the cities used in the estimation of distance measurements. Mean travel time to nearest town was estimated at 0.40 hours and mean distance at 15 miles. Mean travel time and distance to the nearest city were estimated at 1.10 hours and 46 miles, respectively.

North Delta Area (Submarket D)

The North Delta Area was defined to include Morehouse, Caldwell, East Carroll, Ouachita, West Carroll, Richland, Tensas, Madison, and Franklin parishes. Ouachita Parish includes the Monroe Statistical Metropolitan Area.

Descriptive statistics of selected land characteristics for the North Delta Area are presented in Table 4.7. Median and mean land prices were estimated at $699 and $745 per acre, respectively. The mean tract size was estimated at 278 acres. The minimum land value was estimated at $215 per acre and the maximum at $2,000 per acre.

Respondents reported sales indicating that, on average, the proportion of land used in the production of crops, pasture, and timber was 77, 4, and 12 percent, respectively. Median and mean land values associated with this land uses were estimated at $719 and $774 per acre, respectively, and mean tract size at 307 acres.

Major crops reported in the North Delta Area included cotton, soybeans, corn, rice, and vegetables. The highest mean land values estimated for this area was associated with land in rice production ($844 per acre), followed by cotton ($821 per acre). However, $844 per acre is the smallest mean land value estimated for all submarket areas involving rice as

Table 4.7. Mean land values and other characteristics, North Delta Area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
North Delta Area summary	499					
Price per acre ($)		215	2,000	699	744.87	282.35
Size (acres)		10	4,758	123	278.27	421.15
Percent of land in crop, pasture and timber	385					
Price per acre ($)		215	2,000	719	773.81	291.20
Size (acres)		10	4,748	145	306.73	454.65
Percent cropland				91	77.37	31.07
Percent pastureland				0	4.16	17.39
Percent timberland				0	11.69	27.34
Sales with cotton as primary commodity	214					
Price per acre ($)		350	1,800	800	820.95	292.65
Size (acres)		17	2,412	161.5	285.00	337.29
Percent cropland				92	87.07	13.94
Government program base acres		0	1,142	63	119.93	169.17
Sales with soybeans as primary commodity	48					
Price per acre ($)		275	1,013	614.5	613.44	187.05
Size (acres)		34	2,150	80	188.02	345.96
Percent cropland				93	87.29	14.23
Sales with corn as primary commodity	10					
Price per acre ($)		490	917	703	709	135.47
Size (acres)		50	1,089	181	357	386.06
Percent cropland				95	91.5	7.76
Government program base acres		0	120	0	12	97.94
Sales with rice as primary commodity	32					
Price per acre ($)		335	1,282	818.5	843.84	270.47
Size (acres)		62	4,758	407	827.47	924.76
Percent cropland				95	93.16	6.21
Government program base acres		0	1,153	162	228.84	261.80
Sales with vegetables as primary commodity	7					
Price per acre ($)		400	1,000	713	686.86	247.30

(table continued)

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Size (acres)		30	188	80	96.29	62.33
Percent cropland				99	92.71	11.74
Sales with beef as primary commodity	10					
Price per acre ($)		215	755	488	485.9	142.12
Size (acres)		396	114	59	66.1	29.52
Percent pastureland				93.5	86.2	21.90
Sales with cutover pine as primary commodity	7					
Price per acre ($)		300	2,000	725	811.71	574.30
Size (acres)		10	182	40	58.57	57.68
Percent timberland				90	76.86	30.69
Sales with premerchantable pine timber as primary commodity	8					
Price per acre ($)		275	1,200	725.5	757.75	287.42
Size (acres)		15	120	52.5	56.25	34.69
Percent timberland				100	99.75	0.71
Distance measurements	499					
Time to nearest town (hours)		0.03	1.52	0.4	0.40	0.18
Distance to nearest town (miles)		2	59	14.2	14.77	7.48
Time to nearest city (hours)		0.25	2.57	1.2	1.21	0.34
Distance to nearest city (miles)		8.6	122.3	55.3	54.05	16.23

primary commodity. Similarly, sales with beef as primary commodity were estimated to have the smallest mean land value ($486 per acre) of all submarket areas in beef production. Land values for tracts involving cutover pine as primary commodity were estimated at $812 per acre, and mean tract size at 59 acres. For land with premerchantable pine timber, estimated mean per acre value and tract size were $758 and 56 acres, respectively.

Travel time and distance estimates were developed using Street Atlas USA computer software. Results of these estimates are presented in Table 4.7. Bastrop, Columbia, Lake Providence, Monroe, Oak Grove, Rayville, St. Joseph, Tallulah, and Winnsboro are the parish seats and Monroe is the city used in the estimation of distance variables. The estimated mean travel time to the nearest town and city were 0.40 and 1.21 hours, respectively. The estimated mean distance to the nearest town and city were 15 and 54 miles, respectively.

Southwest Area (Submarket E)

Southwest Area includes Vermilion, Cameron, Acadia, Jefferson Davis, Lafayette, Allen, and Calcasieu parishes. Lake Charles and Lafayette are the metropolitan statistical areas included in this study area.

Summary statistics for sales in the Southwest Area are given in Table 4.8. The median and mean estimated land values were estimated at $1,005 and $1,713 per acre, respectively. The minimum and maximum land values were estimated at $238 and $9,688 per acre, with the maximum land values associated with sales closed to Lafayette and Lake Charles statistical metropolitan areas. Mean tract size was estimated at 119 acres, with a minimum of 10 acres and a maximum of 3,496 acres.

Estimated proportion of land dedicated to the production of crops, pasture, and timber are presented in Table 4.8. Estimates indicated that the mean proportions of cropland,

Table 4.8. Mean land values and other characteristics, Southwest Area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Southwest Area summary	524					
Price per acre ($)		238	9,688	1,005	1,713.20	1,630.93
Size (acres)		10	3,496	46.5	119.35	222.82
Percent of land in crop, pasture and timber	299					
Price per acre ($)		238	6,393	880	1,073.49	707.58
Size (acres)		10	3,496	65	146.70	270.33
Percent cropland				89	66.13	40.71
Percent pastureland				0	17.24	34.93
Percent timberland				0	10.58	29.07
Sales with soybeans as primary commodity	30					
Price per acre ($)		300	1,978	900	996.5	422.68
Size (acres)		10	173	40	47.7	35.80
Percent cropland				95	88.03	20.66
Sales with sugar cane as primary commodity	10					
Price per acre ($)		676	4,300	1,605.5	1,829.1	1,063.29
Size (acres)		20	586	60.5	148.4	175.39
Percent cropland				89.5	82.2	29.29
Sales with rice as primary commodity	186					
Price per acre ($)		380	3,500	875	973.28	418.55
Size (acres)		13	3,496	115	203.80	327.69
Percent cropland				92	79.63	30.89
Government program base acres		0	995	31.5	69.09	120.48
Sales with beef as primary commodity	28					
Price per acre ($)		425	4,285	980.5	1,188.11	814.40
Size (acres)		12	152	40	51.75	30.55
Percent pastureland				95.5	75.14	36.63
Sales with cutover pine as primary commodity	7					
Price per acre ($)		325	1,700	1,164	1,063.71	503.00
Size (acres)		10	160	43	70.14	66.40
Percent timberland				100	88.57	22.68

(table continued)

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Distance measurements	524					
Time to nearest town (hours)		0.05	2.07	0.38	0.42	0.27
Distance to nearest town (miles)		1.5	78.4	13.85	15.64	9.22
Time to nearest city (hours)		0.15	1.68	0.7	0.72	0.32
Distance to nearest city (miles)		3	69.4	31	30.10	14.34

pastureland, and timberland were 66, 17, and 11 percent, respectively. Soybeans, sugarcane and rice were reported to be the main crops produced in the area. Land used in the production of sugarcane had the highest estimated per acre land value ($1,829), followed by soybeans ($997), and rice ($973). The mean tract size was estimated at 48 acres for tracts in the production of soybeans, 148 acres for sugarcane, and 204 acres for rice. Estimated land sales reporting to have cutover pine as primary commodity ranged from $325 to $1,700 per acre with median and mean estimated land values of $1,164 and $1,064 per acre, respectively.

Estimates of distance measurements presented in Table 4.8 were calculated using Street Atlas USA computer software. Abbeville, Cameron, Crowley, Jennings, Lafayette, Oberlin, Lake Charles, and Ville Platte were used in the estimation of travel time and distances to the nearest town, and Lake Charles and Lafayette were used in the estimation of travel time and distance to the nearest city. On average, estimated travel time (0.42 hours) and distance (16 miles) to the nearest town was smaller than distance (30 miles) and travel time (0.32 hours) to the nearest city.

<u>Central Delta Area (Submarket F)</u>

The Central Delta Area was defined to include Catahoula, Avoyelles, Pointe Coupee, St. Landry, and Concordia parishes. Descriptive statistics of selected land characteristics are presented in Table 4.9. Land values were estimated to range from $236 to $2,829 per acre, with a median of $727 per acre and a mean of $862 per acre. Tract size was estimated to range from 10 to 6,516 acres. The median tract size was estimated at 105 acres and the mean tract size at 360 acres.

Estimates from responses on land use indicate that 64 percent was cropland, 16 percent pastureland, and 11 percent timberland. The mean land value was estimated at $855

Table 4.9. Mean land values and other characteristics, Central Delta Area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Central Delta Area summary	342					
Price per acre ($)		236	2,829	727	861.55	444.99
Size (acres)		10	6,516	105	359.58	761.85
Percent of land in crop, pasture and timber	236					
Price per acre ($)		2,829	742.5	742.5	854.46	423.56
Size (acres)		10	6,516	107	399.32	845.24
Percent cropland				89	63.52	41.61
Percent pastureland				0	15.74	33.59
Percent timberland				0	11.43	27.53
Sales with cotton as primary commodity	46					
Price per acre ($)		459	1,774	963.5	978.76	296.78
Size (acres)		12	2,429	163	345.35	517.86
Percent cropland				93	82.15	28.19
Government program base acres		0	433	0	62.16	109.95
Sales with soybeans as primary commodity	84					
Price per acre ($)		300	2,002	621.5	714.07	334.70
Size (acres)		10	5,889	113.5	295.06	706.90
Percent cropland				91.5	85.67	19.85
Sales with sugar cane as primary commodity	17					
Price per acre ($)		523	1,850	1,250	1,224.12	383.39
Size (acres)		15	954	117	218.41	258.60
Percent cropland				95	76.19	35.01
Sales with corn as primary commodity	16					
Price per acre ($)		579	1,850	1,000	1,071.5	367.27
Size (acres)		11	2,160	66	274.94	553.12
Percent cropland				94	93.56	5.20
Government program base acres		0	690	0	71.94	180.53
Sales with rice as primary commodity	13					
Price per acre ($)		395	1,215	700	722.23	255.29
Size (acres)		34	6,516	804	1,478.39	2,132.41

(table continued)

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Percent cropland				89	75.62	35.20
Government program base acres		0	3,000	33	357.15	860.18
Sales with beef as primary commodity	24					
Price per acre ($)		408	2,750	956.5	1,095.04	617.32
Size (acres)		13	574	63.5	88.92	111.45
Percent pastureland				90	74.21	33.77
Sales with merchantable hardwood timber as primary commodity	7					
Price per acre ($)		313	886	372	495.14	207.18
Size (acres)		70	3,910	850	1,197.86	1,363.02
Percent timberland				100	75.29	38.20
Distance measurements	342					
Time to nearest town (hours)		0.08	1.33	0.48	0.50	0.22
Distance to nearest town (miles)		2.5	51.5	18	18.44	8.22
Time to nearest city (hours)		0.37	2.2	0.98	1.09	0.39
Distance to nearest city (miles)		15.4	89.8	43.2	45.67	15.43

per acre, and the mean tract size at 345 acres for these sales. According to the respondents, soybeans, cotton, sugarcane, corn, and rice were the primary commodities produced in this area. The mean land value for tracts in soybeans production was estimated at $714 and the mean tract size at 295 acres. Mean land value for tracts with sugarcane as primary commodity was estimated at $1,224 per acre. Land sales with corn as primary commodity were estimated to have a mean value of $1,072 per acre, the highest reported value of all the submarkets having corn as a major enterprise. The mean value for land in rice was estimated at $722 per acre, the lowest reported for all submarkets. However, the estimated mean average tract size for land in of rice was the largest for all the submarkets (1,478 acres). Mean land value for sales reporting beef as primary commodity was estimated at $1,095 per acre and mean tract size at 89 acres.

Mean land value for sales with merchantable hardwood timber was estimated at $495 per acre, and the mean tract size at 1,198 acres. This acreage is the largest for all submarkets in which merchantable hardwood timber was reported as the primary commodity.

Estimates of distance and travel time are reported in Table 4.9. Distance and travel time to nearest town and city were estimated using Street Atlas USA. Jonesville, Marksville, New Roads, Opelousas, and Vidalia are the parish seats and Lafayette, Baton Rouge, Alexandria, and Monroe the cities use in the calculation of distance measurements. Mean travel time and distance to nearest town were estimated at 0.50 hours and 18 miles, respectively, while mean travel time and distance to nearest city were estimated at 1.09 hours and 46 miles, respectively.

<u>Southeast Area (Submarket G)</u>

The Southeast Area is defined to include East Baton Rouge, Washington, East Feliciana, Livingston, St. Helena, Tangipahoa, West Feliciana, and St. Tammany. East

Baton Rouge Parish includes the Baton Rouge metropolitan statistical area. Estimates presented in Table 4.10 summarize selected land characteristics for this area. Median and mean land values were estimated at $2,193 and $2,996 per acre, respectively. Compared to the rest of the submarket areas in Louisiana, these are the highest estimated mean and median land values. The minimum and maximum per acre land values were estimated at $293 and $20,350, respectively. There is, however, a large variability in land values as reflected by the standard deviation ($2,599 per acre). Median and mean tract size were estimated at 66 and 119 acres with a minimum of 10 acres and a maximum of 1,180 acres.

Estimated percentages of cropland, timberland, and pasture are presented in table 4.10. Respondents reported timber as the main land use (52 percent), followed by pasture (40 percent), and crops (two percent). The median and mean per acre land values for tracts with beef as primary commodity were estimated at $1,966 and $2,383, respectively. These estimated median and mean land values are the largest for all the submarket areas. Mean land value with dairy as primary commodity was estimated at $1,276, and the mean tract size at 180 acres.

Timberland had the largest estimated land values and acreage of all submarkets. Median and mean values for tracts with cutover pine as primary commodity were estimated at $1,250 and $1,504 per acre, respectively. Median and mean land values for tracts with premerchantable pine were estimated at $1,450 and $1,829 per acre, respectively, and the mean tract size at 161 acres. Land values for sales with merchantable pine timber were estimated at $2,820 per acre, while those with merchantable hardwood timber were estimated at $2,361 per acre.

Table 4.10. Mean land values and other characteristics, Southeast Area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Southeast Area summary	540					
Price per acre ($)		293	20,350	2,193	2,996.45	2,598.96
Size (acres)		10	1,180	66	118.81	157.60
Percent of land in crop, pasture and timber	323					
Price per acre ($)		474	13,750	2,000	2,480.53	1,771.18
Size (acres)		10	975	95	137.98	141.89
Percent cropland				0	2.46	14.08
Percent pastureland				30	40.38	39.99
Percent timberland				50	51.86	40.75
Sales with beef as primary commodity	59					
Price per acre ($)		600	8,660	1,966	2,382.97	1,682.68
Size (acres)		10	773	109	150.85	147.17
Percent pastureland				87	76.47	26.74
Sales with dairy as primary commodity	18					
Price per acre ($)		749	1,700	1,374	1,275.61	291.07
Size (acres)		10	270	180.5	153.72	64.80
Percent pastureland				75	62	38.09
Sales with cutover pine as primary commodity	8					
Price per acre ($)		600	4,500	1,250.5	1,504.37	1,241.76
Size (acres)		40	1,180	119.5	238.63	384.62
Percent timberland				90	68.88	43.90
Sales with premerchantable pine timber as primary commodity	12					
Price per acre ($)		744	4,500	1,450	1,828.67	1,323.33
Size (acres)		13	410	141.5	161.42	133.63
Percent timberland				91	67	43.22
Sales with merchantable pine timber as primary commodity	24					
Price per acre ($)		768	6,949	2,859.5	2,819.75	1,287.66
Size (acres)		20	583	78	127.58	123.96
Percent timberland				100	89.17	23.38

(table continued)

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Sales with premerchantable hardwood timber as primary commodity	5					
Price per acre ($)		1,775	4,500	2,250	2,650.2	1,075.31
Size (acres)		27	100	73	65.8	27.36
Percent timberland				84	69.8	41.60
Sales with merchantable hardwood timber as primary commodity	29					
Price per acre ($)		474	6,027	2,563	2,360.79	1,353.35
Size (acres)		24	582	147	193.38	131.05
Percent timberland				97	91.66	15.29
Distance measurements	540					
Time to nearest town (hours)		0.02	1.3	0.45	0.48	0.27
Distance to nearest town (miles)		1	48	18	19.91	11.74
Time to nearest city (hours)		0.25	2.18	1.12	1.11	0.31
Distance to nearest city (miles)		9	89	47	47.02	15.47

Travel time and distance estimates are presented in Table 4.10. Street Atlas USA computer software was used to estimate travel times and distances to the nearest towns and cities. Baton Rouge, Bogalusa, Clinton, Denham Springs, Greensburg, Hammond, St. Francisville, and Slidell were the parish seats and Baton Rouge and New Orleans were the cities used in the estimation of distance measurements. On average, estimated distance (20 miles) and travel time (0.48 hours) to the nearest town were smaller than estimated distance (47 miles) and travel time (1.11 hours) to the nearest city.

Sugarcane Area (Submarket H)

The Sugarcane Area is defined to include St. John the Baptist, Ascension, Terrebonne, St. James, St. Mary, Assumption, Iberia, Iberville, West Baton Rouge, St. Martin, and Lafourche. The parish of Terrebonne includes the Houma metropolitan statistical area.

Estimates presented in Table 4.11 summarize selected characteristics for the study area. The median and mean land values were estimated at $1,461 and $2,088 per acre, respectively. The minimum land value was estimated at $227 per acre and the maximum at $16,000 per acre. Estimated land values show great variability in this area where the estimated standard deviation was $2,192 per acre. Median and mean tract sizes were estimated at 64 and 226 acres, respectively.

Proportions of cropland, pastureland, and timberland were estimated at 52, 18, and 16 percent, respectively. Estimated mean land value and tract size were $1,935 per acre and 249 acres, respectively. Sugarcane was the most frequently reported primary commodity by respondents in the area. The mean land value for tracts of land with sugarcane as primary enterprise was estimated at $1,584 per acre, and the mean tract size at 301 acres. This is the largest reported mean tract size among all submarkets reporting sugarcane as primary

Table 4.11. Mean land values and other characteristics, Sugarcane Area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Sugarcane Area	270					
Price per acre ($)		227	16,000	1,460.5	2,087.79	2,192.38
Size (acres)		10	2,959	64	225.78	456.51
Percent of land in crop, pasture and timber	168					
Price per acre ($)		314	16,000	1,382.5	1,934.85	1,951.92
Size (acres)		10	2,959	77	248.68	437.39
Percent cropland				62.5	52.24	43.18
Percent pastureland				0	18.08	34.76
Percent timberland				0	15.51	31.12
Sales with sugar cane as primary commodity	106					
Price per acre ($)		314	6,500	1,332.5	1,584.00	1,017.25
Size (acres)		10	2,959	90.5	301.16	483.62
Percent cropland				85	70.30	34.35
Sales with beef as primary commodity	20					
Price per acre ($)		384	10,110	1,181.5	1,918.1	2,274.15
Size (acres)		17	2,405	63.5	219.4	525.01
Percent pastureland				95	78.4	29.37
Sales with cutover hardwood as primary commodity	5					
Price per acre ($)		534	1,109	625	765.2	249.40
Size (acres)		68	234	82	116.8	68.36
Percent timberland				96	89	19.18
Sales with merchantable hardwood timber as primary commodity	5					
Price per acre ($)		694	1,221	917	936.4	207.15
Size (acres)		141	874	285	384.4	286.50
Percent timberland				100	95.8	9.39
Distance measurements	270					
Time to nearest town (hours)		0.03	1.68	0.37	0.47	0.32
Distance to nearest town (miles)		1.1	59.5	12.8	16.11	11.63

(table continued)

Selected land characteristics	Number of sales reported	Minimum	Maximum	Median	Mean	Standard deviation
Time to nearest city (hours)		0.1	1.53	0.68	0.71	0.30
Distance to nearest city (miles)		2.4	54.1	24.2	24.95	10.67

commodity. Mean land value for sales with beef as primary commodity was estimated at $1,918 per acre, and mean tract size at 219 acres.

Sales with cutover hardwood as primary commodity were estimated to have a mean value of $765 per acre and mean tract size of 117 acres. Mean land values of sales involving merchantable hardwood timber as primary enterprise were estimated at $936 per acre, and the mean tract size at 384 acres.

Distance measurements appear in the last section of Table 4.11. Distances and travel time estimates were calculated using the Street Atlas USA computer software. Laplace, Donaldsonville, Houma, Lutcher, Morgan City, Napoleonville, New Iberia, Plaquemine, Port Allen, St. Martinsville, and Thibodaux are the parish seats, and Houma, Baton Rouge, and Lafayette are the cities used in the estimation of travel times and distances to the nearest cities. Mean travel time and distance to the nearest town were estimated at 0.47 hours and 16 miles, respectively, while mean travel time and distance to the nearest city were estimated at 0.71 hours, and 25 miles, respectively.

Summary

Estimates of mean per acre rural land values were characterized by substantial variation across submarket areas. Median and mean land values for all sales in Louisiana were estimated at $962 and $1,448 per acre, respectively. Distribution of median and mean land values, by submarket, are presented in Figure 4.8. In general, estimated median values are lower than estimated mean values for all areas. The highest estimated median and mean land values corresponded to the Southeast submarket followed by the Sugarcane Area. The lowest estimated median and mean land values belonged to North Delta and North Central submarket areas. The size of tracts also presented wide ranges and large standard deviations across submarkets. The median and mean tract sizes were estimated at 59 and 162 acres,

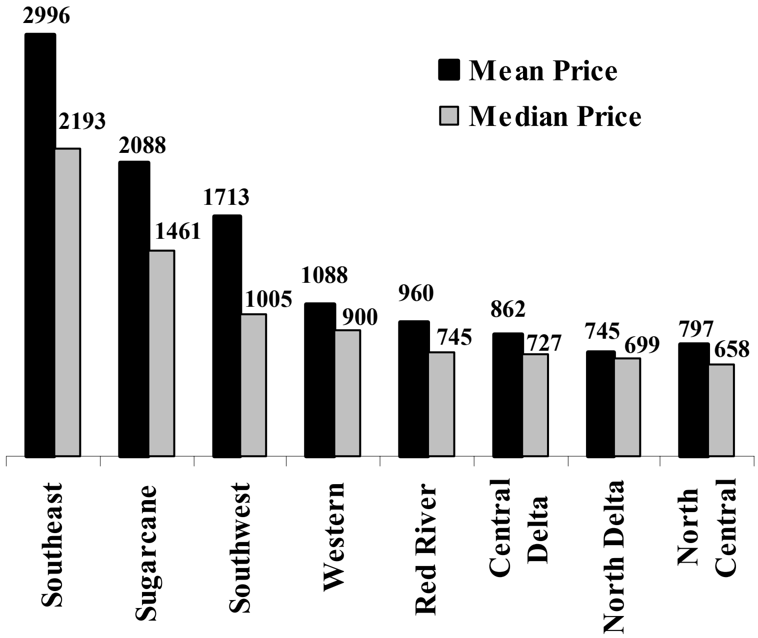

Figure 4.8. Median and mean land value distribution, by submarket area, Louisiana Rural Land Value Survey, January 1, 1993 to June 30, 2002 sale period.

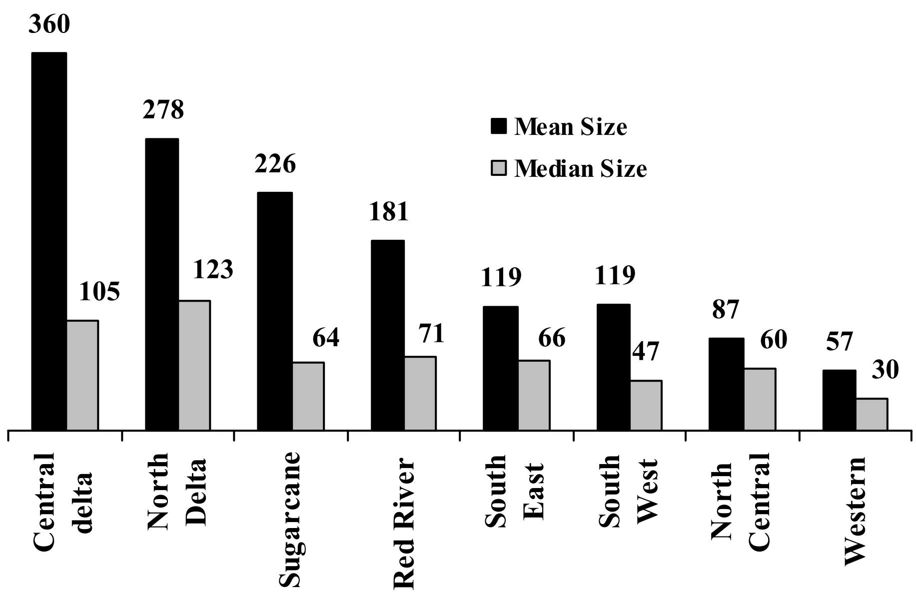

Figure 4.9. Median and mean tract size distribution by submarket areas, Louisiana Rural Land Market Survey, January 1, 1993 to June 30, 2002 sale period.

respectively. Estimates of mean and median tract size by submarket area illustrated in Figure 4.9. The largest estimated median and mean tract sizes were found in the Central Delta and North Delta submarket areas, while the smallest sizes corresponded to the Western and North Central submarket areas.

Respondents indicated that the most frequent reason for purchase was expansion of land holdings, with investment, residential, establishing a farm, and recreational, following, respectively (Figure 4.6). The less frequently mentioned reason for purchase was commercial. They also indicated that residential and recreational are the other two factors that influence rural lands values the most (Figure 4.7). Other factor affecting land values were the presence of a highway, flood and urban development. Less frequent influences on land values were the presence of ponds in the tract and the potential for commercial land use.

These data suggest substantial variability in per acre land values. In the next chapter, factors, such as size of the tract, time of sale, proportion of land in the production of crops, pasture, and timber; soil productivity, primary commodities produced, distance to nearest town, distance to nearest city, and other factors, are used to model the rural land market. Moreover, these factors are used to explain variability in rural land values. A hedonic analysis will be used to assess the importance of land characteristics on land values.

CHAPTER 5 . HEDONIC ESTIMATES

The purpose of this study is to conduct a spatial analysis of the dynamics of rural land values in Louisiana. This chapter presents the results of the statistical models estimated for eight of the nine submarkets in Louisiana. The New Orleans submarket was not included because it generally does not include rural land. For testing the assumptions of the model, ordinary least squares statistical procedures were conducted using SpaceStat computer software (Anselin, 1995). Diagnostic tests conducted included testing for normality of the errors, multicollinearity, heteroskedasticity, spatial autocorrelation in the data, and selection of the spatial model. For each one of the eight submarkets, ordinary least squares and maximum likelihood spatial hedonic models were estimated using the Spatial Statistic Toolbox 2 (Pace, 2003) computer program. Finally, marginal implicit prices were estimated to show the effects that land characteristics included in this study have on per acre rural land values.

Hedonic Model Estimation

Three basic steps were followed in the estimation of the hedonic model. First, the hedonic models were estimated using ordinary least squares (OLS) regression procedures. Second, statistical tests were conducted to verify that model assumptions held using results from the OLS regression. Also, measures of fit were estimated for the OLS regression. Third, hedonic models were estimated using maximum likelihood (ML) spatial estimation procedures. Measurements of fit were estimated for the ML spatial model and compared to those of the OLS model.

Verification of Model Assumptions

Assumptions of the regression model are: approximately normal errors with expected values of zero, homoskedasticity, zero covariances in the error term, and independence of the error term from the regressors. Data for this study consist of spatial cross-sectional data of independent observations that were collected over a nine year period. Given the nature of the data, it is necessary to test for heteroskedasticity (non-constant variance), spatial autocorrelation (observations clustering together in space), multicollinearity (highly correlated independent variables), and normality of the errors. Biased estimates of standard errors, inaccurate predicted values, and inefficient least squares estimates may result from disregarding the presence of any of these problems.

Initially, hedonic models were estimated using ordinary least squares (OLS) regression procedures. Based on results from the OLS estimation, econometric tests were conducted using algorithms available with SpaceStat (Anselin, 1995).

Multicollinearity was tested using the condition number. Multicollinearity is the high correlation between observations of the explanatory variables included in the regression model. As a rule of thumb, condition number values larger than 20 are considered to be problematic.

Tests for normality of the errors were conducted using the Kiefer-Salmon test. The Kiefer-Salmon test assumes that errors are distributed normally. If the null hypothesis is rejected at the ten percent level of significance, it indicates that there is no reason to reject normality of the errors. The rejection of the null hypothesis presents a potential problem for validity of further tests. However, because of the large number of observations in the data set, the probability of rejecting the null hypothesis is high. To verify that rejection of normality was due to the number observations, normal Q-Q plots were generated using SAS computer algorithms. Results from the Kiefer-Salmon normality test and the normal Q-Q plots for all areas indicated that normality of the residuals is not a problem.

Heteroskedasticity was tested using the Lagrange Multiplier test developed by Breusch and Pagan (Breusch-Pagan test). Heteroskedasticity is the situation where the random regression error does not have a constant variance over all observations The Breusch-Pagan test assumes homoskedastic errors. Results from the Breusch-Pagan indicated failure to reject the null hypothesis of homoskedastic disturbance terms in the data for all submarket areas.

Serial autocorrelation was tested using the Durbin-Watson test using SAS computer software. Results from the test indicated that serial autocorrelation was not a problem in the data for all submarket areas.

In order to test for spatial autocorrelation, the hedonic model was estimated using ordinary least squares. Spatial autocorrelation was tested using the Lagrange Multiplier test. Spatial autocorrelation, or spatial dependence, is the situation where the dependent variable or error term at each location is correlated with observations of the dependent variable or values for the error term at other locations. The presence of autocorrelation is tested with the Lagrange Multiplier (LM) test. LM follows a χ^2 with one degree of freedom and the null hypothesis is the absence of spatial dependence. LM test is also used for selection of the type of spatial model that best fits the data. When comparing spatial lag versus spatial error models, a higher LM estimate or lower probability number indicates which spatial error model best fits the data.

Spatial Hedonic Model Estimation

Once the presence of autocorrelation was confirmed, the next step was to construct hedonic models for each submarket. The two models most cited in the literature for real estate price estimation are the spatial lag and the spatial error models. The Lagrange Multiplier test was used in the selection of the best spatial model for each submarket.

The construction of the weight is an essential part in the formulation of a spatial econometric model. Pace (2003) suggests two basic types of spatial weight matrices that can apply to real estate data analysis. One is the Delaunay weight matrix in which a triangulation process is used to assign weights to observations based on the proximity to their neighbors. The autoregressive parameter alpha is the only parameter used in the construction of the weights making the Delaunay matrix. The other approach is the nearest neighbor spatial weight matrix influenced by a decaying function. The decaying function depends on the number of neighbors and a decaying parameter rho. These two parameters affect the rate at which the decaying function affects the weight matrix. Therefore, the nearest neighbor weight matrix depends on three parameters, the autoregressive parameter alpha, the number of neighbors, and the rho parameter, that add flexibility to the matrix. In a recent study, Soto et al. (2004) compared the use of the Delaunay and the nearest neighbor weight matrix and found that the models in which the latter was used had a better fit. To choose the values of rho and number of neighbors (m), a repetitive process involving combination of rho ranging from 0.05 to one at increments of 0.05 with neighbors ranging from one to 30 was conducted. Then, the spatial model with the combination of rho and m that achieved the largest log likelihood number, for each specific market, was selected.

Once the appropriate weight matrix was selected, hedonic regression analyses, for each submarket, were estimated using maximum likelihood spatial procedures. Hence, in the following section, a table for each submarket was constructed to present the results from the hedonic model estimation. Ordinary least squares and maximum likelihood estimates along with respective signed root deviations (SRDS)[10] , in parenthesis, are presented in each

[10] Signed root deviances (SRDS) are similar to t-values and interpreted in a similar way (Pace, 2003).

table. Log likelihood numbers were estimated to calculate likelihood ratio tests used to compare ordinary least squares and maximum likelihood spatial models. The likelihood ratio test is also used in this study to identify the presence of spatial autocorrelation. The formulation of the likelihood ratio test is:

$$LR = 2 \times [L_U - L_R] \tag{4.1}$$

where L_U, and L_R are the log likelihood values of the unrestricted and the restricted models, respectively. In this study, the restricted model is the ordinary least squares, and the unrestricted model is the maximum likelihood spatial model. The likelihood ratio test follows a χ^2 with one degree of freedom ($\chi^2_{(1,\ \alpha=0.05)} = 3.84$) and the null hypothesis is no difference between the ordinary least squares and the maximum likelihood models. Therefore, a statistically significant likelihood ratio value indicates that the spatial error model is a better model by incorporating the spatial component.

The last part of hedonic model estimation consisted of estimating marginal implicit prices. Marginal implicit prices show the effect that land characteristics included in this study have on per acre rural land values.

<u>Submarket A: Western Area</u>

Estimated rural land value models are presented in Table 5.1. Hypothesized variables for the models were statistically significant and had the expected signs. For instance, natural log of size of tract (LNSIZE) was highly significant at the one percent level, and exhibited a negative relationship with per acre land value. The negative influence was expected because a relatively larger number of potential buyers compete for small tracts as opposed to relatively fewer buyers that compete for larger sized tracts. The coefficient for distance to the nearest town (DNT) was significant at the one percent level. The negative sign reflected

Table 5.1. Estimated hedonic OLS and spatial error models, Western Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable[a]	Ordinary least squares estimates	Maximum likelihood error model estimates
LNSIZE	-0.25542143	-0.2569847
	(-10.3921)***	(-10.41726)***
TIME	0.004182262	0.003953487
	(7.46603)***	(7.38130)***
PR	0.253067996	0.259172952
	(3.11316)***	(3.04613)***
S5	0.213068	0.23056925
	(4.16987)***	(4.14015)***
VALUE	0.000000789	0.00000085
	(2.33152)**	(2.55953)**
DNT	-0.01265943	-0.01280827
	(-5.29774)***	(-4.54742)***
RESINF	0.41203489	0.342537162
	(2.41064)*	(1.93315)*
INTERCEPT	7.580348981	7.597090720
	(41.5003)***	(32.24552)***
ALPHA		0.33500000
		(4.19558)***
Rho		0.8
Number of Neighbors (m)		20
Multicollinearity Condition Number	12.74	
Lagrange Multiplier Test (Error)	28.9580	
	[0.0000]	
Lagrange Multiplier Test (Lag)	0.004705	
	[0.945312]	
Log Likelihood Number	-2347.36	-2338.56
Likelihood Ratio Test (LR)		17.6
Number of Observations	835	835

Signed Root Values are in parentheses, ***denotes statistical significance at the 0.01 level, ** denotes statistical significance at the 0.05 level, and * denotes statistical significance at the 0.10 level. Values in brackets are probabilities.

[a]Percentage of cropland (CROP) was not significant at the ten percent level.

higher transportation costs for tracts located further from principal markets. In this study, types of soils were assigned by geo-referencing the location of reported sales using Louisiana GIS CD, and ArcGIS computer software. The positive coefficient for the Western Pleistocene Terraces-terraces soils (S5) reflects that buyers are willing to pay a premium for deep, permeable and well drained soils.

Tests were conducted to verify the validity of the ordinary least squares model. The magnitude of the multicollinearity condition number (13) did not suggest multicollinearity problems. Results from Lagrange Multiplier (LM) tests indicated the presence of spatial autocorrelation. The LM error estimated value of 29 is greater than that of the LM lag of 0.94, indicating that the spatial error model is a better model.

The spatial error model was estimated using the nearest neighbor weight matrix. Rho is a decay parameter that ranges from 0.05 to one, and m is the number of closest neighbors. The combination of rho and number of neighbors (m) that yielded the largest log likelihood number for the spatial error model was 0.80 and 20, respectively. The coefficient alpha (autoregressive coefficient) for the spatial error model was statistically significant at the one percent level, indicating the presence of spatial autocorrelated errors. Likewise, estimated log likelihood numbers indicated that the maximum likelihood spatial model better fit the data. The likelihood ratio test indicated that the spatial error model best fit the data ($\chi^2 = 17.6 > \chi^2_{(1,0.05)} = 3.84$).

<u>Submarket B: Red River Area</u>

Estimated rural land value models for the Red River Area are presented in Table 5.2. Coefficients for the hypothesized variables for the models were statistically significant and had the expected signs. For example, the coefficient for percentage of cropland (CROP) was estimated to be positive, as expected. This variable represents the most profitable land planted in the best soil for that crop, generating the largest revenue stream from agricultural use. The estimated coefficient for percent of timberland (TIMBER) was negative, because the majority of the timber may be cutover timber on land that is not suitable for other purposes, such as crops or residential land. The coefficient for reason for purchase residential (RPR) was estimated to be positive. This sign was expected because of urban competition for rural land in the urban fringe areas of Shreveport and Alexandria. The estimate for establishment of a farm (RPF) was negative, indicating that there are no premiums associated with farmland bought for expansionary reasons.

Validity of assumptions of the ordinary least squares model was tested. The multicollinearity condition number (17) did not suggest multicollinearity problems. Results from the Lagrange Multiplier (LM) tests indicated the rejection of the null hypothesis of independent errors. Therefore, there are problems associated with spatial autocorrelation of the errors. A LM error value of 29 is larger than that of the LM lag value of 1.53, indicating that the error model is the best spatial model for fitting this data set.

The spatial error model was estimated using a nearest neighbor weight matrix. The nearest neighbor matrix depends on three parameters, the autoregressive parameter alpha, a decay parameter rho, and the number of neighbors. Alpha was obtained from the estimation of the spatial error model. The combination of rho and number of neighbors that yielded the highest log likelihood number for the spatial error model was 0.5 and 16, respectively. The autoregressive coefficient alpha was highly significant at the one percent level, indicating the presence of spatial autocorrelation. Likewise, log likelihood value for the maximum

Table 5.2. Estimated hedonic OLS and spatial error model, Red River Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Ordinary least squares estimates	Maximum likelihood error model estimates
LNSIZE	-0.247243	-0.235212
	(-9.13113)***	(-8.60267)***
CROP	0.00256205	0.0027354
	(3.17241)***	(3.38672)***
TIMBER	-0.0018178	-0.001544
	(-2.84851)***	(-2.42628)**
TIME	0.006690	0.0070660
	(9.10685)***	(9.43782)***
PR	0.2411471	0.2618545
	(4.51012)***	(4.91746)***
S5	0.125931	0.1223976
	(2.15225)**	(1.90732)*
VALUE	0.00001102	0.0000109
	(9.05242)***	(9.15673)***
INVTC	0.15652268	0.1695510
	(4.79816)***	(4.30980)***
RPRES	0.27178161	0.207284
	(3.38662)***	(2.59713)***
RPF	-0.2704480	-0.24382
	(-2.40823)**	(-2.25948)**
HWYINF	0.3801683360	0.4030587
	(2.79274)***	(3.00379)***
INTERCEPT	6.930207291	6.8235946
	(26.66443)***	(20.73857)***
ALPHA		0.4830000
		(3.36742)***
Rho		0.50
Number of Neighbors		16
Multicollinearity Condition Number	16.98	
Lagrange Multiplier Test (Error)	28.9580	
	[0.0000]	
Lagrange Multiplier Test (Lag)	1.353886	
	[0.244600]	
Log Likelihood Number	-649.93	-641.26
Likelihood Ratio Test		17.34
Number of Observations	319	319

Signed Root Values are in parentheses, ***denotes statistical significance at the 0.01 level, ** denotes statistical significance at the 0.05 level, and * denotes statistical significance at the 0.10 level. Values in brackets are probabilities.

likelihood model (-641) is larger than for the ordinary least squares model (-650), indicating that the maximum likelihood model is better. Furthermore, the likelihood ratio test value ($\chi^2 = 17.34 > \chi^2_{(1,0.05)} = 3.84$) indicated that the spatial error models best fit the data.

Submarket C: North Central Area

Estimated rural land value models for the North Central Area are presented in Table 5.3. Hypothesized variables for the model estimated by ordinary least squares and maximum likelihood were statistically significant and had the expected signs. For example, North Central Area respondents indicated that pasture and timber were the highest and best uses of land. The coefficients for the two variables included to account for these attributes, percent of pastureland (PAST) and percent of timberland (TIMBER), were positive, as expected. Percent of pastureland in the tract may add to the value of rural land, depending on the extent of the improvements. A positive coefficient for percent of timberland may be related to the presence of merchantable and pre-merchantable timber, reflecting the willingness of buyers to pay a premium for ready-to-sell timber. Flood influence (FLINF) was one of the most frequent answers from the respondents. This negative coefficient for flood influence was expected because land that has flooded in the past becomes a potential flooding area that lowers the price of land. The discrete variable paved road (PR) had the expected positive coefficient. The positive coefficient was expected because a paved road represents ease of access and enhances development potential. The coefficient for the Western Pleistocene Terraces–floodplains soils (S6) was negative. The negative coefficient reflects that these deep, very poorly drained, and slowly permeable soils are not suitable for agriculture.

Several tests were conducted to verify that assumptions of the ordinary least squares model hold. The multicollinearity condition number of 18.35 suggests that there are no

Table 5.3. Estimated hedonic OLS and spatial error models, North Central Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable[a]	Ordinary least squares estimates	Maximum likelihood error model estimates
LNSIZE	-0.19607505	-0.1938863
	(-5.80159)***	(-5.79628)***
PAST	0.004750001	0.004826677
	(5.17119)***	(4.14462)***
TIMBER	0.00222909	0.00199107
	(3.03322)***	(2.62907)***
TIME	0.007549385	0.00756481
	(7.39254)***	(7.38095)***
PR	0.205958684	0.178376481
	(3.49454)***	(2.86968)***
S6	-0.14057403	-0.1237605
	(-2.05177)**	(-1.76052)*
VALUE	0.000009882	0.000009837
	(5.39317)***	(5.49706)***
INVTT	0.303805886	0.31737828
	(2.85441)***	(2.66591)***
FLINF	-0.35124707	-0.31935484
	(-3.05963)***	(-2.73985)***
INTERCEPT	6.429218557	6.42068375
	(20.90562)***	(17.18998)***
ALPHA		0.33000
		(2.16629)***
Rho		0.30
Number of Neighbors		9
Multicollinearity Condition Number	18.35	
Lagrange Multiplier Test (Error)	7.241530	
	[0.007124]	
Lagrange Multiplier Test (Lag)	0.914556	
	[0.338908]	
Log Likelihood Number	-369.02	-366.17
Likelihood Ratio Test (LR)		5.7
Number of Observations	213	213

Signed Root Values are in parentheses, ***denotes statistical significance at the 0.01 level, ** denotes statistical significance at the 0.05 level, and * denotes statistical significance at the 0.10 level. Values in brackets are probabilities.

[a]Percentage of cropland (CROP) was not significant at the ten percent level. The influence of Shreveport MSA was not significant at the ten percent level.

correlations between observations for the explanatory variables. The value of the Lagrange Multiplier (LM) indicates the presence of spatial autocorrelation in the errors. The LM error estimate (7.24) is larger than the LM lag estimate (0.91), suggesting that the spatial error model is better.

A nearest neighbor weight matrix was used in the estimation of the maximum likelihood spatial error model. Rho represents a decay parameter that ranges from 0.05 to one, and m is the number of neighbors that ranges from one to 30. The values for rho and number of neighbors used in this model are 0.60 and 26, respectively. This combination of decaying factors yielded the spatial error model with the highest log likelihood number. The autoregressive parameter alpha for the spatial error model was statistically significant at the one percent level, indicating the presence of autocorrelation. The log likelihood number for the spatial error model (-366) was larger than the log likelihood number for the ordinary least squares model (-369), indicating that the spatial model is the best model. Moreover, the value likelihood ratio test ($\chi^2 = 5.7 > \chi^2_{(1,0.05)} = 3.84$) indicated the better performance of the spatial model in fitting the data.

Submarket D: North Delta

Estimated rural land value models for the North Delta Area are presented in Table 5.4. Hypothesized variables for the models estimated by ordinary least squares and maximum likelihood were significant and had the expected signs. For instance, the coefficient for the variable inverse of travel time to the nearest city (INVTC) was positive, as expected. A negative sign for travel time to the nearest city reflects higher transportation costs for tracts located further from principal markets. The positive sign reflects the reciprocal of the negative relationship. The coefficient for reason for purchase recreational

Table 5.4. Estimated hedonic OLS and spatial models, North Delta Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable[a]	Ordinary least squares estimates	Maximum likelihood error model estimates
TIME	0.004739661	0.004561242
	(9.59798)***	(9.57263)***
INVTC	0.102282473	0.131945108
	(2.50074)**	(2.25199)***
RPREC	-0.16636104	-0.14912219
	(-2.00606)**	(-1.84949)*
RPRES	0.213743160	0.192567931
	(1.98304)**	(1.84369)*
VALUE	0.000001677	0.000001231
	(2.74905)***	(2.17750)**
CB	0.20481040	0.186247692
	(6.67957)***	(6.24108)***
INTERCEPT	6.149080864	6.140054640
	(42.91991)***	(28.16632)***
ALPHA		0.695000000
		(6.95800)***
Rho		0.60
Number of Neighbors		26
Multicollinearity Condition Number	7.2079	
Lagrange Multiplier Test (Error)	28.115431	
	[0.00000]	
Lagrange Multiplier Test (Lag)	0.348171	
	[0.555150]	
Log Likelihood Number	-977.71	-953.51
Likelihood Ratio Test		48.4
Number of Observations	499	499

Signed Root Values are in parentheses, ***denotes statistical significance at the 0.01 level, ** denotes statistical significance at the 0.05 level, and * denotes statistical significance at the 0.10 level. Values in brackets are probabilities.

[a]LNSIZE was not significant at the ten percent level. Percentage of cropland (CROP) was not significant at the ten percent level. PR was not significant at the ten percent level.

(RPREC) was negatively related to the price of land. The negative sign was expected because these tracts of land are bought primarily for hunting, and they have no value for other uses that could generate more rent. The coefficient for total value of improvements (VALUE) was estimated to positively affect rural land values. The addition of houses, dwellings, fences, and irrigation canals are expected to increase the value of a tract of land.

Over 30,000 acres of cotton base acreage were reported by 194 respondents in the North Delta Area. For this reason, a dummy variable indicating the presence of cotton base (CB) was included in the hedonic model. The coefficient for cotton base estimate was positive, as expected. The positive sign was expected because crop base acreage represents potential income through government program payments that will increase per acre land values.

Statistical tests were conducted to verify the validity of the assumptions of the ordinary least squares model. The value of the multicollinearity condition number (7.2) did not suggest multicollinearity problems. Estimates from Lagrange Multiplier (LM) tests indicated the presence of spatial autocorrelation. The LM error estimate of 28 is larger than that of the LM lag of 0.35, indicating that the spatial model best fit the data.

A nearest neighbor weight matrix was used in the estimation of the maximum likelihood spatial error model. The decay parameter rho, and the number of neighbors are used in the estimation of the weight matrix. Rho is a decay parameter that ranges from 0.05 to one, and m ranges from one to 30. The combination of rho and number of neighbors that yielded the highest log likelihood number for the spatial error model were 0.6 and 26, respectively. The autoregressive coefficient alpha was highly significant at the one percent level, indicating the presence of spatial autocorrelation. Additionally, the log likelihood number for the spatial error model (-953) was larger than the one of the OLS model (-978), indicating the better fit of the spatial error model. Similarly, the likelihood ratio test value indicated that the spatial error model best fit the data ($\chi^2 = 48 > \chi^2_{(1,0.05)} = 3.84$).

Submarket E: Southwest Area

Estimated rural land value models for the Southwest Area are presented in Table 5.5. Hypothesized variables for both models were statistically significant at the one percent level and had the expected signs. For example, the coefficient for percent of timberland (TIMBER) was negative. The negative sign could be the result of the presence of cutover timber that will not generate rents. The coefficient for travel time to the nearest town (TNT) was negative, as expected. The negative sign indicated higher transportation costs for tracts located further from principal markets. The coefficient for commercial influence (COMINF) had the expected positive sign. The positive sign reflected the importance of the potential for commercial land use for future income stream.

For the Southwest Area, dummy variables were included to estimate the hypothesized difference in the variation of the rural land values between Calcasieu Parish and the rest of the study area. This difference is due to higher per acre sales prices for tracts reported in Calcasieu Parish. To model this difference, two slope variables and one intercept variable were included in the models. Calcasieu natural log of size (CALNSIZE) and Calcasieu month of sale (CALTIME) are the two slope variables, and CALCASIEU is the intercept variable, if the tract is located in Calcasieu Parish. The coefficient for the CALCASIEU intercept was positive indicating that tracts of land located in Calcasieu Parish had a higher value than the ones located elsewhere. The coefficients for slope variables for month of sale and size if tracts were located in Calcasieu Parish had the expected positive and negative

Table 5.5. Estimated hedonic OLS and spatial error models, Southwest Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable[a]	Ordinary least squares estimates	Maximum likelihood error model estimates
TIMBER	-0.00562329	-0.00372251
	(-4.43922)***	(-4.011781)***
TIME	0.003440104	0.003550442
	(3.98236)***	(5.474586)***
TNT	-0.29690876	-0.40320873
	(-2.48404)**	(-2.68422)***
COMINF	0.932066615	0.949046555
	(3.28691)***	(4.56036)***
CALCASIEU	1.45019509	1.42636658
	(4.52846)***	(4.77942)***
CALNSIZE	-0.38564858	-0.34670052
	(-6.14483)***	(-6.86807)***
CATIME	0.006854823	0.005773696
	(2.86244)***	(3.37167)***
INTERCEPT	6.99676868	7.072829086
	(38.98319)***	(20.93486)***
ALPHA		0.9880
		(17.60880)***
Rho		0.8
Number of Neighbors		20
Multicollinearity Condition Number	12.4950	
Lagrange Multiplier Test (Error)	24.795358	
	[0.000001]	
Lagrange Multiplier Test (Lag)	5.055239	
	[0.024552]	
Log Likelihood Number	-1383.47	-1228.44
Likelihood Ratio Test		310.01
Number of Observations	524	524

Signed Root Values are in parentheses, ***denotes statistical significance at the 0.01 level, ** denotes statistical significance at the 0.05 level, and * denotes statistical significance at the 0.10 level. Values in brackets are probabilities.

[a]LNSIZE was not significant at the ten percent level. Percentage of cropland (CROP) was not significant at the ten percent level. Rice base was not significant at the ten percent level.

signs, respectively. The negative coefficient for the size of tract was expected because a relatively smaller number of potential buyers compete for larger sized tracts in Calcasieu Parish.

Statistical tests were conducted to verify the validity of the ordinary least squares models. The magnitude of the multicollinearity condition number (12) did not suggest high correlation between the observations for the explanatory variables included in the model. Results from the Lagrange Multiplier (LM) tests indicated the presence of spatial autocorrelation. Moreover, the estimated LM error value of 24 was larger than that of the LM lag of five, indicating that the spatial error model is a better model.

The spatial error model was estimated by incorporating a nearest neighbor weight matrix. Rho is a decay parameter that ranges from 0.05 to one, and m is the number of neighbors that ranges from one to 30. The values of rho and number of neighbors that best fit the spatial error model (largest likelihood number) were 0.80 and 20, respectively. The autoregressive coefficient alpha from the spatial error model was statistically significant at the one percent level, indicating the presence of spatial autocorrelation in the errors. In addition, the log likelihood numbers indicated that the maximum likelihood spatial model better fit the data ($-1228_{ML} > -1383_{OLS}$). Likewise, the value of likelihood ratio test indicated that the spatial model was a better model ($\chi^2 = 310 > \chi^2_{(1,0.05)} = 3.84$).

Submarket F: Central Delta Area

The estimated rural land value models for the Central Delta Area are presented in Table 5.6. Hypothesized variables for the hedonic models were statistically significant and had the corrected signs. For instance, the coefficient for paved road access (PR) was positive and statistically significant at the one percent level. The discrete variable paved road (PR) had the expected positive coefficient. The positive coefficient was expected because a paved road represents ease of access and enhances development potential. The coefficient for reason for purchase recreational (RPREC) was negative. The negative sign was expected because recreational land is usually bought for hunting and it has no value for other uses that could generate more rent. The coefficient for residential influence (RESINF) was positive, as expected. The positive sign was expected because rural land with a potential for residential development competes for rural land in the urban fringe areas of Monroe and Alexandria. The coefficient for the presence of cotton base (CB) was positive and statistically significant at the five percent level. The positive sign was expected because cotton base represents a potential for government payments.

Statistical tests were conducted to verify the validity of the ordinary least squares model. A multicollinearity condition number of 15 did not suggest multicollinearity problems. Results from Lagrange Multiplier (LM) tests indicated the presence of spatial autocorrelation. The LM error estimated value of 24 was greater than that of the LM lag of 5.29, indicating that the spatial error model was a better model.

The spatial error model was estimated using a nearest neighbor weight matrix. Rho is a decay parameter used in the construction of the weight matrix that ranges from 0.05 to one, and m is the number of closest neighbors. The combination of rho and number of neighbors that yielded the largest log likelihood number for the spatial error model was 0.50 and 20, respectively. The autoregressive coefficient alpha for the spatial error model was statistically significant at the one percent level, indicating the presence of spatial autocorrelation. Estimated log likelihood numbers indicated that the maximum likelihood model better fit the

Table 5.6. Estimated hedonic OLS and spatial error models, Central Delta Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable[a]	Ordinary least squares estimates	Maximum likelihood error model estimates
LNSIZE	-0.08953239	-0.09016454
	(-5.48459)***	(-5.51008)***
TIME	0.005781479	0.005214376
	(8.18580)***	(7.39013)***
PR	0.254295927	0.215496044
	(6.13019)***	(5.39263)***
INVTC	0.199958654	0.203447108
	(3.54700)***	(2.68158)***
RPREC	-0.31847336	-0.26102158
	(-3.19277)***	(-2.73703)***
RESINF	0.290087049	0.335312322
	(2.31931)**	(2.88484)***
FLINF	-0.31148549	-0.30235789
	(-2.83916)***	(-2.99594)***
CB	0.149213278	0.159848347
	(2.0414)**	(2.27018)**
INTERCEPT	6.506805401	6.542110454
	(27.84850)***	(21.40918)***
ALPHA		0.62300
		(5.17491)***
Rho		0.5
Number of Neighbors		20
Multicollinearity Condition Number	15.223765	
Lagrange Multiplier Test (Error)	23.617664	
	[0.000001]	
Lagrange Multiplier Test (Lag)	5.294959	
	[0.21387]	
Log Likelihood Number	-651.70	-638.31
Likelihood Ratio Test		26.78
Number of Observations	342	342

Signed Root Values are in parentheses, ***denotes statistical significance at the 0.01 level, ** denotes statistical significance at the 0.05 level, and * denotes statistical significance at the 0.10 level. Values in brackets are probabilities.

[a] Percentage of cropland (CROP) was not significant at the ten percent level.

data than the ordinary least squares model (-638ML>-652OLS). In addition, the value of the LR indicated that the spatial error model best fit the data ($\chi^2 = 27 > \chi^2_{(1,0.05)} = 3.84$).

Submarket G: Southeast Area

Estimated rural land models for the Southeast Area are presented in Table 5.7. Hypothesized variables for the models were statistically significant and had the correct expected signs. For example, the coefficient for the variable TIME was positive. The positive coefficient was expected because of the effects of upper trend in values and inflation during the survey period. The coefficient for a tract of land located in Saint Tammany Parish (ORLEANS) was positive. The positive sign was expected because the closer a tract of land is to the New Orleans MSA the higher its value. The coefficient for the inverse of travel time to the nearest city (INVTC) was positive. There is an inverse relationship between travel time and land values, because the longer it takes to get to a principal market, the higher the transportation costs. However, a positive sign was expected, because it represents the reciprocal of the travel-time relationship. Coefficients for reason for purchase recreational (RPRECR) and commercial (RPCOM) were negative and positive, respectively. The negative sign for purchase for recreational purposes was expected because recreational land in this area is mostly marshland. The positive sign for reason for purchase commercial was expected because of commercial competition for rural land in the urban fringe areas of Baton Rouge and New Orleans.

The validity of assumptions of the hedonic model estimated by ordinary least squares was statistically tested. The magnitude of the multicollinearity condition number (13) did not suggest multicollinearity problems. The assumption of independence of the errors was tested using Lagrange Multiplier (LM) tests. LM estimates indicated the presence of spatial

Table 5.7. Estimated hedonic OLS and spatial error models, Southeast Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable[a]	Ordinary least squares estimates	Maximum likelihood error model estimates
LNSIZE	-0.27629863	-0.27733759
	(-10.6938)***	(-12.14097)***
TIME	0.00581456	0.006965293
	(7.48650)***	(9.78209)***
ORLEANS (ST. TAMMANY)	0.481890757	0.446650907
	(7.43578)***	(3.06763)***
VALUE	0.000002454	0.000001876
	(5.8489)***	(5.24374)***
INVTC	0.190626245	0.289856422
	(3.04813)***	(2.57994)***
RPREC	-0.24012815	-0.21425924
	(-2.19718)**	(-2.28751)**
RPCOM	0.584651498	0.620078961
	(2.10789)**	(2.61627)***
INTERCEPT	8.219253278	8.041205692
	(33.28390)***	(19.97267)***
ALPHA		0.946000000
		(11.858306)***
Rho		0.80
Number of Neighbors		25
Multicollinearity Condition Number	12.68997	
Lagrange Multiplier Test (Error)	12.667298	
	[0.000372]	
Lagrange Multiplier Test (Lag)	0.129770	
	[0.718670]	
Log Likelihood Number	-1372.17	-1303.00
Likelihood Ratio Test (LR)		138.34
Number of Observations	541	541

Signed Root Values are in parentheses, ***denotes statistical significance at the 0.01 level, ** denotes statistical significance at the 0.05 level, and * denotes statistical significance at the 0.10 level. Values in brackets are probabilities.

[a]Percentage of cropland (CROP) was not significant at the ten percent level. Percentage of timberland (TIMBER) was not significant at the ten percent level.

autocorrelation. The value of LM error (13) was greater than the value of the LM lag (0.13), indicating that the spatial error model was the best model.

The maximum likelihood spatial error model was estimated using the nearest neighbor weight matrix. Rho is a decay parameter used in the construction of the weight matrix that ranges from 0.05 to one, and m is the number of closest neighbors. The parameters rho and number of neighbors (m) that reached the highest log likelihood number for the spatial model were 0.80 and 25, respectively. The autoregressive coefficient alpha for the spatial error model was statistically significant at the one percent level, indicating the presence of spatial autocorrelated errors. The log likelihood number for the maximum likelihood spatial error model was estimated at -1303, which is larger than the one for the least squares model at -1372, indicating that the error model better fit the data. In addition, the value of the likelihood ratio test indicated that the spatial error model is the best model ($\chi^2 = 138 > \chi^2_{(1,0.05)} = 3.84$).

<u>Submarket H: Sugarcane Area</u>

Estimated rural land value models for the Sugarcane Area are presented in Table 5.8. Hypothesized variables for the models were statistically significant and had the correct expected signs. For example, natural log of size of tract (LNSIZE) was highly significant at the one percent level, and exhibited a negative relationship with per acre land value. The negative influence was expected because a relatively larger number of potential buyers compete for small tracts as opposed to relatively fewer buyers that compete for larger sized tracts. The coefficient for the Subtropical Mississippi Valley Alluvium-natural levees soils (S19) was positive and statistically significant at the one percent level. The positive coefficient reflects that buyers are willing to pay a premium for natural levee soils that are

Table 5.8. Estimated hedonic OLS and spatial error models, Sugarcane Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable[a]	Ordinary least squares estimates	Maximum likelihood error model estimates
LNSIZE	-0.30084308	-0.29662657
	(-9.54365)***	(-9.59109)***
TIME	0.00230493	0.002799213
	(1.98307)**	(2.45329)**
S19	0.164866019	0.140382433
	(1.92842)*	(1.67115)*
INVTC	0.061430578	0.120629763
	(2.19863)**	(2.62183)***
RPREC	-0.50122763	-0.59077085
	(-2.61190)***	(-3.58952)***
RPINV	0.256499489	0.304490584
	(2.33661)**	(3.27372)***
INTERCEPT	8.367537108	8.23200848
	(26.24054)***	(17.76843)***
ALPHA		0.902000
		(8.52396)***
Rho		0.70
Number of Neighbors		14
Multicollinearity Condition Number	10.628624	
Lagrange Multiplier Test (Error)	35.209098	
	[0.00000]	
Lagrange Multiplier Test (Lag)	0.015613	
	[0.900562]	
Log Likelihood Number	-614.37	-578.04
Likelihood Ratio Test		36.33
Number of Observations	270	270

Signed Root Values are in parentheses, ***denotes statistical significance at the 0.01 level, ** denotes statistical significance at the 0.05 level, and * denotes statistical significance at the 0.10 level. Values in brackets are probabilities.

[a]Percentage of cropland (CROP) was significant at the ten percent level, but not with the expected sign. PR was not significant at the ten percent level.

usually fertile soils for agriculture. The coefficient for reason for purchase recreational (RPREC) was negative, as expected. The negative sign was expected because most of the tracts used for recreational purposes are marshlands; therefore, they cannot have a more profitable land use. The coefficient for reason for purchase investment (RPINV) had the expected positive sign. The positive sign was expected because of the future income stream it is expected to produce.

Statistical tests were conducted to verify the validity of assumptions of the ordinary least squares model. The value of the multicollinearity test (11) indicates that there is no problem of correlation between observations for the explanatory variables. Lagrange Multiplier (LM) test results indicated the presence of spatial autocorrelation. The LM error estimated value of 35 was greater than that of the LM lag of 0.01, indicating that the spatial error model is the best model.

A nearest neighbor spatial weight matrix was used in the estimation of the spatial error model. Rho and number of neighbors are parameters used in the estimation of the spatial weight matrix. Rho is a decay parameter that ranges from 0.05 to one, and m is the number of neighbors. The values of rho and number of neighbors (m) that yielded the highest likelihood number for the error model test were 0.70 and 14, respectively. The autoregressive coefficient alpha for the spatial error model was statistically significant at the one percent level, indicating the presence of spatial autocorrelated errors. The log likelihood number for the spatial error model (-578) was larger than that of the ordinary least squares model (-614), indicating that the spatial error model best fit the data. Additionally, the value of LR test ($\chi^2 = 36 > \chi^2_{(1,0.05)} = 3.84$), indicated that the spatial error model best fit the data.

Marginal Implicit Prices of Land Characteristics

The last part of the hedonic model estimation consisted of calculating the marginal implicit prices. Marginal implicit prices help to observe the magnitude and direction of influence of location and economic development on per acre land values. Estimates from hedonic models are used in the construction of marginal implicit prices. For convenience, marginal implicit prices are evaluated at mean values of per acre price and of the characteristic. A positive marginal implicit price suggests that an increase in a particular characteristic results in an increase in per acre price of rural land, other things held constant. A negative marginal implicit price resulting from a negative coefficient has a depressing effect on per acre real estate prices, other things constant.

Western Area Marginal Implicit Prices

Marginal implicit prices (MIP) estimated for the Western Area are presented in Table 5.9. Marginal implicit prices were calculated using hedonic model estimates generated by ordinary least squares (OLS) and maximum likelihood (ML) econometric procedures, and evaluated at the mean price ($1,088.16 per acre) and mean characteristic level for LNSIZE (56.97 acres).

Table 5.9. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic level, Western Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Marginal implicit prices from OLS model results ($)/acre	Marginal implicit prices from spatial model results ($) /acre
LNSIZE	-4.88	-4.87
TIME	4.57	4.29
PR	316.96	345.30
S5	256.69	271.59
VALUE (10,000)	8.59	8.78
DNT (miles)	-13.82	-13.76
RESINF	530.96	425.78

As expected, the MIP of natural log of size (LNSIZE) varied inversely proportional with per acre price. The MIP for LNSIZE obtained from the OLS estimate suggests that land price declines by $4.88 per acre with a one-acre increase in tract size. For the variable month of sale (TIME), marginal implicit price obtained from the OLS estimate implies that a one-month increase in the time of sale will increase per acre rural land value by $4.57.

The marginal implicit price for paved road (PR) suggests that, for the Western Area, a tract with paved road access could sell for $317 more per acre than a tract that does not have paved road access. The marginal implicit price for tracts in the Western Pleistocene Terraces-terraces soils (S5) suggests that these tracts are valued at $257 per acre more than tracts found in other soils.

A marginal implicit price for the distance to nearest town (DNT) suggests that a one-mile increase from the largest town, in the Western area, will decrease per acre value by $14. Marginal implicit prices for residential influence (RESINF) obtained from ML and OLS estimates were $426 and $531, respectively. A MIP of $426 suggests that tracts of land located in areas for potential residential development could be sold for $426 per acre more than tracts with other types of influence. Statistical measures of fit estimates suggest that the MIP of $426 per acre for RESINF is better than that of the OLS measure of $531 per acre. The difference in MIP for RESINF values suggests that MIP obtained from OLS estimates could have been overestimated by 20 percent.

<u>Red River Area Marginal Implicit Prices</u>

Marginal implicit prices for the Red River area are presented in Table 5.10. Marginal implicit prices (MIP) were calculated using hedonic model estimates generated by ordinary least squares (OLS) and maximum likelihood (ML) procedures, and evaluated at the mean price ($960.09 per acre) and mean characteristic levels for LNSIZE and INVTC (181.38 acres, and 1.67 hours, respectively).

The estimated marginal implicit price for percent cropland (CROP) from the OLS estimate suggests that each percent increase of tract in cropland raises the per acre price of rural land by $2.46, meaning that if the tract of land is 100 percent cropland, the total value would be $246 more per acre. MIPs for percent of land devoted to timberland production (TIMBER) obtained from OLS and ML estimates were -$1.75 and -$1.48, respectively. A MIP of -$1.75 suggests that for each percent increase of tract in timberland, the value of land is expected to decrease by $1.75 per acre. Statistical measures of fit estimates suggest that the MIP of -$1.48 per acre for TIMBER is better than that of the OLS measure of -$1.75 per acre. The difference in MIP values suggests that MPI obtained from OLS estimates could have been underestimated by 15 percent.

Table 5.10. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic levels, Red River Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Marginal implicit prices from OLS model results ($)/acre	Marginal implicit prices from spatial model results ($)/acre
LNSIZE	-1.31	-1.25
CROP	2.46	2.63
TIMBER	-1.75	-1.48
TIME	6.42	6.78
PR	260.08	285.62
S5	126.99	122.77
VALUE (10,000)	105.82	104.38
INVTC (hours)	-54.02	-58.51
RPRES	295.79	217.38
RPF	-232.11	-212.10
HWYINF	431.12	463.71

The marginal implicit price for the inverse of travel time to the nearest city (INVTC) estimated from the OLS estimate suggests that a one-hour increase from the largest city will decrease the value of rural land by $54 per acre. The marginal implicit price for total value of improvements (VALUE) suggests that, on average, for every $10,000 of improvements, rural land would be sold for $106 per acre more than tracts with no improvements.

Marginal implicit price for reason for purchase residential (RPRES) obtained from the OLS (MIP_{OLS}) estimate suggests that tracts bought for residential reasons are typically valued at $296 more per acre than tracts purchased for other reasons in the Red River Area. When compared to the MIP for RPRES obtained from the ML estimator of $217, it seems that the MIP_{OLS} was overestimated by 27 percent. Statistical measures of fit estimates suggest that the MIP of $217 per acre for RPRES is better than that of the OLS measure of $296 per acre. The opposite happened when the reason for purchase was to establish a farm (RPF). According to the results, the MIP_{OLS} for RPF indicated that tracts purchased for the establishment of a farm would be valued at $232 per acre less than tracts purchased for other reasons. The estimated implicit price for highway influence (HWYINF) obtained from the OLS estimate suggests that rural land could be sold for $431 per acre more when there is potential development related to the construction of a highway.

North Central Area Marginal Implicit Prices

Marginal implicit prices estimated for the North Central Area are presented in Table 5.11. Marginal implicit prices (MIP) were calculated using hedonic model estimates generated by ordinary least squares (OLS) and maximum likelihood (ML) spatial econometric procedures, and evaluated at the mean price ($797.33 per acre) and mean characteristic levels for LNSIZE and INVTT (87.03 acres and 0.97 hours, respectively).

The marginal implicit price for percent of tract in pastureland (PAST) obtained from the OLS estimate suggests that each percentage increase in improved pasture in the North Central Area results in an increase of $3.79 per acre. Therefore, a tract of land that is 100 percent in improved pasture could be sold for $379 per acre more than a tract with no

Table 5.11. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic levels, North Central Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Marginal implicit prices from OLS model results ($)/acre	Marginal implicit prices from spatial model results ($)/acre
LNSIZE	-1.80	-1.78
PAST	3.79	3.85
TIMBER	1.78	1.59
TIME	6.02	6.03
PR	180.65	153.86
S6	-106.19	-94.56
VALUE (10,000)	78.80	78.43
INVTT (hours)	-258.12	-269.66
FLINF	-239.85	-221.90

pastureland. Similarly, the implicit price for percent of timberland (TIMBER) obtained from the OLS estimate suggests that each percentage increase in timberland results, on average, in an increase of $1.78 per acre in the North Central Area. The MIP for TIMBER obtained from the ML estimate was $1.59, indicating that the MIP obtained from the OLS estimate could have been overestimated by eleven percent. Statistical measures of fit estimates suggest that the MIP of $1.59 per acre for TIMBER is better than that of the OLS measure of $1.78 per acre.

Marginal implicit prices for the presence of paved road access (PR) obtained from OLS and ML estimates were $181 and $154, respectively. Tracts with paved road access could sell for $181 more than they would otherwise. There is a difference of $28 among MIP values for PR, indicating that MIP obtained by OLS estimates could have been overestimated by 15 percent. Statistical measures of fit estimates suggest that the MIP of $154 per acre for PR is better than that of the OLS measure of $181 per acre. The MIP for Western Pleistocene Terraces–floodplains soils (S6) obtained from the OLS estimate suggests that tracts in these soils would be valued at $106 per acre less than tracts in other general soil areas.

The MIP for the total value of improvements (VALUE) obtained from the OLS estimate suggests that $10,000 in improvements on a tract would increase per acre land values by $79 per acre, other factors held constant. The marginal implicit price for the inverse of travel time to the nearest town (INVTT) obtained from the OLS estimate indicates that a one-hour increase from the largest parish town, in the North Central Area, will decrease rural land value by $258 per acre. The MIP price for flood influence (FLINF) obtained from OLS estimates suggests that tracts of land located in areas of potential flooding would be valued at $240 per acre less than tracts of land located in non-flooding areas.

<u>North Delta Area Marginal Implicit Prices</u>

Marginal implicit prices (MIPs) estimated for the North Delta Area are presented in Table 5.12. MIPs were calculated using hedonic model estimates generated by ordinary least squares (OLS) and maximum likelihood (ML) econometric procedures, and evaluated at the mean price ($744.87 per acre) and mean characteristic level for INVTC (0.91 hours, respectively).

The MIP for the inverse of travel time to the nearest city (INVTC) obtained from the OLS estimate suggests that a one-hour increase in travel time to the nearest city decreases land value by $91 per acre. However, the MIP for INVTC obtained from the ML estimate is -$118, indicating that the MIP estimated from the OLS estimate could have been underestimated by 22 percent. Statistical measures of fit estimates suggest that the MIP of -$118 per acre for INVTC is better than that of the OLS measure of -$91 per acre.

Marginal implicit price of reason for purchase recreational (RPREC) obtained from the OLS estimate suggests that tracts bought for recreational reasons, in the North Delta Area, are typically valued at $116 per acre less than tracts purchased for other reasons. On

Table 5.12. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic level, North Delta Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Marginal implicit prices from OLS model results ($)/acre	Marginal implicit prices from spatial model results ($)/acre
TIME	3.53	3.40
INVTC (hours)	-91.34	-117.83
RPREC	-116.32	-105.27
RPRES	172.16	153.27
VALUE (10,000)	12.49	9.27
CB	168.87	152.09

the other hand, the MIP of reason for purchase residential (RPRES) obtained from the OLS estimate implies that, a tract purchased for the reason of residence would be valued at $172 per acre more than tracts purchased for other reasons.

MIP for the presence of cotton base acreage (CB) obtained from the OLS estimate indicates that a tract with cotton base acreage would be valued at $169 per acre more than a tract without cotton base acreage. The MIP for CB obtained from the ML estimate was $152, indicating that the MIP obtained from the OLS estimate was overestimated by ten percent. Statistical measures of fit estimates suggest that the MIP of $152 per acre for CB is better than that of the OLS measure of $169 per acre.

<u>Southwest Area Marginal Implicit Prices</u>

Marginal implicit prices (MIP) for the Southwest Area are presented in Table 5.13. MIPs were estimated from ordinary least squares (OLS) and maximum likelihood (ML) model results, and evaluated at the mean price ($1,713.20 per acre).

The MIP for percent timberland (TIMBER) obtained from the OLS estimate was -$9.63, whereas the MIP obtained from the ML estimate was -$6.38, indicating that the MIP obtained from the OLS estimate could have been overestimated by 33 percent. A MIP of -$9.63 indicates that each percentage increase in the percent of tract in timberland decreases

Table 5.13. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic levels, Southwest Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Marginal implicit prices from OLS model results ($)/acre	Marginal implicit prices from spatial model results ($)/acre
TIMBER	-9.63	-6.38
TIME	5.89	6.08
CALTIME	11.74	9.89
TNT (hours)	-508.66	-690.78
COMINF	2,466.43	2,617.61
CALCASIEU	5,226.65	5,109.09
CALNSIZE	-660.69	-593.97

the per acre price of land by $9.63. Statistical measures of fit estimates suggest that the MIP of -$6.38 per acre for TIMBER is better than that of the OLS measure of -$6.38 per acre. This result means that if a tract of land is 100% in timberland the reduction in price would be $683 per acre.

Estimated marginal implicit price for month of sale (TIME) obtained from the OLS estimate suggests that a one-month increase in the time of sale increases rural land value by $6 per acre. Moreover, if the tract of land is located in Calcasieu Parish, the marginal implicit price of month of sale (CALTIME) suggests that a one-month increase in the time of sale would increase land value by $12 per acre.

The MIP for travel time to the nearest town (TNT) obtained from the OLS estimate indicates that a one-hour increase in travel time to the nearest town would decrease land value by $509 per acre. When compared to the MIP value obtained from the ML estimate (-$691), it suggests that the MIP obtained from OLS could have been underestimated by 26 percent. Statistical measures of fit estimates suggest that the MIP of -$691 per acre for TNT is better than that of the OLS measure of -$509 per acre. The MIP for commercial influence (COMINF) obtained from the OLS estimate suggests that land associated with potential commercial use would be sold at $2,466 per acre more than land influenced by other factors.

The MIP for Calcasieu intercept (CALCASIEU) obtained from the OLS estimate indicates that a tract of land located in Calcasieu Parish would be sold at $5,226 more per acre than a tract that is located outside Calcasieu Parish, in the Southwest Area. The MIP for the size of the tract of land in Calcasieu Parish (CALNSIZE) obtained form the OLS estimate indicates that land price declines by $594 per acre with a one acre increase in tract size in Calcasieu Parish.

<u>Central Delta Area Marginal Implicit Prices</u>

Marginal implicit prices (MIP) estimated for the Central Delta Area are presented in Table 5.14. MIPs were calculated using hedonic model results conducted by ordinary least squares (OLS) and maximum likelihood (ML) econometric procedures, and evaluated at the mean price ($861.54 per acre) and mean characteristic levels for LNSIZE and INVTC (359.58 acres and 1.04 hours, respectively).

The MIP for paved road access (PR) obtained from the OLS estimate suggests that a tract with paved road access could sell for $248 more per acre than a tract that does not have paved road access. The MIP for PR obtained from the ML estimate was $206, indicating that the MIP obtained from the OLS estimate could have been overestimated by 17 percent. Statistical measures of fit estimates suggest that the MIP of $206 per acre for PR is better than that of the OLS measure of $248 per acre.

The MIP for reason for purchase recreational (RPREC) obtained from the OLS estimate suggests that a tract sold for recreational purposes would be valued $238 less per acre than tracts purchased for other reasons. Statistical measures of fit estimates suggest that the MIP of $201 per acre for RPREC is better than that of the OLS measure of $238 per acre.

Table 5.14. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic levels, Central Delta Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Marginal implicit prices from OLS model results ($)/acre	Marginal implicit prices from spatial model results ($)/acre
LNSIZE	-0.21	-0.22
TIME	4.98	4.49
PR	248.50	206.33
INVTC (hours)	-158.19	-160.95
RPREC	-238.09	-200.94
RESINF	280.97	335.11
FLINF	-234.37	-228.03
CB	135.97	146.83

The MIP for flood influence (FLINF) obtained from the OLS estimate implies that tracts of land situated in areas of potential flooding would be valued $234 less per acre than tracts without a potential for flooding. The MIP for the presence of cotton base (CB) obtained from the OLS estimate implies that a tract with cotton base acreage would be valued at $136 more per acre than a tract without cotton base acreage.

Southeast Area Marginal Implicit Prices

Marginal implicit prices estimated for the Southeast Area are presented in Table 5.15. Marginal implicit prices (MIP) were estimated using results from ordinary least squares (OLS) and maximum likelihood (ML) hedonic models, and evaluated at the mean price ($2,996.45 per acre) and mean characteristic levels for LNSIZE and INVTC (118.81 acres and 1.04 hours, respectively).

The MIP for natural log of size (LNSIZE) obtained from the OLS estimate suggests that a one-acre increase in tract size in the Southeast Area would decrease the value of land by $7 per acre. The MIP for month of sale (TIME) obtained from the OLS estimate suggests that price a one-month increase in time of sale increases the land value by $17 per acre. When compared to the MIP for TIME obtained from the ML estimate of $21, results suggest that the MIP obtained from the OLS could have been underestimated by 16 percent. Statistical measures of fit estimates suggest that the MIP of $21 per acre for TIME is better than that of the OLS measure of $17 per acre.

Table 5.15. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic levels, Southeast Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Marginal implicit prices from OLS model results ($)/acre	Marginal implicit prices from spatial model results ($)/acre
LNSIZE	-6.97	-6.99
TIME	17.42	20.87
VALUE (10,000)	73.53	56.22
INVTC (hours)	-584.09	-888.14
ORLEANS	1,845.02	1,637.82
(ST. TAMMANY)		
RPREC	-653.69	-588.48
RPCOM	2,177.39	2,419.89

MIPs for value of improvements (VALUE) obtained from the OLS and the ML estimates were $74 and $56, respectively. A MIP for VALUE of $74 suggests that $10,000 in improvements would increase land values by $74 per acre. The difference in MIP values implies that the MIP obtained from the OLS estimate could have been overestimated by 24 percent. Statistical measures of fit estimates suggest that the MIP of $56 per acre for VALUE is better than that of the OLS measure of $74 per acre.

The MIP for inverse of travel time to the nearest city (INVTC) obtained from the OLS estimate was -$584, whereas the one obtained from the ML estimate was -$888. The MIP for INVTC suggests that a one hour increase in travel time to the nearest city decreases per acre value by $584 per acre for the Southeast Area. Statistical measures of fit estimates suggest that the MIP of -$888 per acre for INVTC is better than that of the OLS measure of -$584 per acre. These results imply that the MIP obtained from the OLS estimate could have been underestimated by 34 percent.

The MIP for a tract of land located in St. Tammany Parish (ORLEANS) obtained from the OLS estimate suggests that a tract of land located in the New Orleans MSA is estimated to be valued at $1,845 more per acre than a tract in the Southeast area not located in the MSA. When compared to the MIP for ORLEANS obtained from the ML estimate ($1,638), results suggest that the MIP obtained from the OLS could have been overestimated by 11 percent. Statistical measures of fit estimates suggest that the MIP of $1,638 per acre for INVTC is better than that of the OLS measure of $1,845 per acre.

The MIP for reason for purchase recreational (RPREC) obtained from the OLS estimate indicates that land purchased for recreational purposes would be valued at $654 less per acre than land bought for other purposes. Finally, the MIP price for reason for purchase commercial (RPCOM) obtained from the OLS estimate suggests that, on average, land bought for commercial purposes would be valued at $2,177 more per acre than land bought for other reasons. MIP values for RPREC and RPCOM obtained from ML estimates were ten percent higher than those estimated from OLS estimates. Statistical measures of fit estimates suggest that MIPs obtained from ML estimates are better than that obtained from OLS estimates

Sugarcane Area Marginal Implicit Prices

Marginal implicit prices estimated for the Sugarcane Area are presented in Table 5.16. Marginal implicit prices (MIP) were estimated using results from hedonic models estimated by ordinary least squares (OLS) and maximum likelihood (ML) econometric procedures, and evaluated at the mean price ($2,087.79 per acre) and mean characteristic levels for LNSIZE and INVTC (225..78 acres and 1.79 hours, respectively).

The MIP for natural log of size (LNSIZE) obtained from the OLS estimate suggests that a one-acre increase on the size of land would decrease the value of land by $2.78 per acre. The MIP for month of sale (TIME) obtained from the OLS estimate implies that a one-month increase on the time of sale would raise the price of land by $4.81 per acre.

Table 5.16. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic levels, Sugarcane Area, Louisiana, January 1, 1993 to June 30, 2002.

Variable	Marginal implicit prices from OLS model results ($)/acre	Marginal implicit prices from spatial model results ($)/acre
LNSIZE	-2.78	-2.74
TIME	4.81	5.84
INVTC (hours)	-40.08	-78.70
S19	365.22	306.20
RPREC	-846.11	-946.92
RPINV	594.26	730.90

The MIP for inverse of travel time to the nearest city (INVTC) obtained from the OLS estimate suggests that a one-hour increase in travel time to the nearest city decreases rural land value by $40 per acre. When compared to the MIP for INVTC obtained from the ML estimate (-$79), results suggest that the MIP obtained from the OLS estimate was underestimated by 49 percent. Statistical measures of fit estimates suggest that the MIP of -$79 per acre for INVTC is better than that of the OLS measure of -$40 per acre.

The MIP for the Subtropical Mississippi Valley Alluvium-natural levees soils (S19) indicates that tracts of this type of land located in the Sugarcane Area would be sold at $365 more than tracts of land located elsewhere. The difference between MIP obtained from OLS and ML estimates was $59, indicating that MIP obtained from the OLS estimate could have been overestimated by 16 percent. Statistical measures of fit estimates suggest that the MIP of $306 per acre for S19 is better than that of the OLS measure of $365 per acre.

The MIP for reason for purchase recreational (RPREC) obtained from the OLS estimate suggests that a tract purchased for the reason of recreation would be valued at $846 less per acre than tracts purchased for other reasons. Finally, the MIP for reason for purchase investment (RPINV) obtained from the OLS estimate suggests that tracts bought for investment reasons would be valued at \$594 more than tracts purchased for other reasons. When compared to the MIP for RPINV obtained from the ML estimate (\$731), results suggest that the MIP obtained from the OLS estimate could have been underestimated by 19 percent. Statistical measures of fit estimates suggest that the MIP of \$731 per acre for RPINV is better than that of the OLS measure of \$594 per acre.

Summary

Hedonic models were used to estimate the effects of rural land characteristics on the value of rural land. Hedonic models for eight submarket areas were estimated using ordinary least squares and maximum likelihood econometric procedures.

Size (LNSIZE) had a statistically significant negative influence on rural land values in six of the eight rural land submarket areas. Month of sale (TIME) was found to have a positive influence on rural land values in five of the eight rural land submarkets. Similarly, the inverse of travel time to the nearest city (INVTC) was estimated to have a positive influence on the price of rural land in six submarket areas.

Estimates obtained from hedonic models were used in the calculation of the marginal implicit prices. Marginal implicit prices help to observe the magnitude and direction of influence that land characteristics have on per acre land values. Marginal implicit prices for the inverse of travel time to nearest city (INVTC) obtained by maximum likelihood estimates were estimated to range from -\$58 per acre in the Red River Area to -\$888 per acre in the Southeast Area. This means that, in the Southeast Area, an hour increase in travel time to the nearest city decreases per acre value by \$888. Marginal implicit prices for paved road access (PR) obtained from ML estimates were estimated to range from \$154 per acre in the North Central Area to \$345 per acre in the Western Area. The marginal implicit price for RT in the

Western Area suggests that a tract of land with paved road access could sell for $345 more per acre than a tract of land that does not have paved road access.

In general, marginal implicit prices obtained form ordinary least squares and maximum likelihood estimates were shown to be different. In some cases, marginal implicit prices obtained from OLS estimates were found to be substantially underestimated or overestimated when compared to marginal implicit prices obtained from ML estimates.

CHAPTER 6 . SUMMARY AND CONCLUSIONS

Many factors, such as productivity, location, accessibility, and alternative uses, determine the value of rural real estate. Continued economic and population growth increases the need for land, which puts upward pressure on the value of rural land. Buyers, sellers, planners, appraisers, tax assessors, and others are expected to have an increasing need for information that measures the effects of location and economic development on rural land values. Important questions relate to the magnitude of these influences and to the spatial extent of these influences in rural land markets. In general, research aimed at identifying factors that may be used in explaining the variation in rural land values is expected to provide improved information for both private and public decisions.

Review of Methods

This study conducted a spatial analysis of the dynamics of rural land values in Louisiana. More specifically, this research sought to: (i) develop procedures for updating rural real estate land values, (ii) test for spatial dependence in the rural real estate data (iii) empirically estimate land value models using spatial econometric procedures (iv) estimate the effect that selected factors have on rural real estate values; and (v) compare and evaluate spatial and traditional rural land value model estimation procedures.

Data for this study include sales that were collected for the time period January 1, 1993 to June 30, 1998, and data collected as a part of this study for the period July 1, 1998 to June 30, 2002. Data were collected utilizing mail survey techniques. The listing included individuals from commercial banks, the Farm Service Agency, Federal Land Bank and Louisiana Agriculture Credit personnel. In addition, it was mailed to members of the Louisiana Real Estate Commission, the Louisiana Chapter of the American Society of Farm

Managers and Rural Appraisers and the Louisiana Realtors Land Institute. Respondents were also provided with the opportunity to respond to the survey electronically.

Hedonic land price models were estimated using both ordinary least squares (OLS) and maximum likelihood (ML) spatial procedures. Initially, hedonic models were estimated by OLS procedures and statistical tests were conducted to verify the assumptions of the OLS model. Since the assumption of independence of error terms did not hold for the OLS models, hedonic models were estimated by ML spatial econometric procedures. Results from Lagrange Multiplier tests not only were used to identify the presence of spatial autocorrelation, but also were used in the selection between the spatial lag and the spatial error models. Once the correct spatial model was selected, hedonic models were estimated by maximum likelihood spatial procedures. A nearest neighbors spatial weight matrix was selected in the construction of the spatial models.

Summary of Louisiana Rural Land Market Survey Results

In order to update the Louisiana rural land market data base, a mail survey was conducted to collect information for the period July 1, 1998 to June 30, 2002. The response rate for this survey period was 27 percent, resulting in 1,041 useful observations. These new data, along with the 2,501 observations collected for the time period January 1993 to June 30, 1998, provided the total 3,542 observations used in this study. Data were organized into nine rural land submarket areas, estimated in a previous study[11], using multivariate statistical techniques and physical and socio-economic variables. Because only two observations were available for the New Orleans Metro Area, this study focused on eight submarkets: Western, Red River, North Central, North Delta, Southwest, Central Delta, Southeast and Sugarcane.

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[11] See Kennedy (1995) for detailed information on Louisiana rural land market delineation.

Statewide results indicated a large amount of variability in per acre rural land values. The mean and the median per acre price of rural real estate were estimated at \$1,448 and \$962, respectively, with a standard deviation estimated at \$1,615 per acre. Mean values were estimated to vary from \$797 per acre for the North Central Area to \$2,996 per acre for the Southeast Area.

For rural land used in the production of crops, pasture, or timberland, the mean and median values were estimated at \$1,237 and \$894 per acre, respectively, with a standard deviation estimated at \$1,186 per acre. Similarly, rural land values varied when classified by primary commodity. Mean values for cropland were estimated to vary from \$749 per acre where soybeans were the primary commodity, to \$1,741 per acre when merchantable pine timber was the primary commodity.

Other information obtained from respondents indicated that the highest and best use for rural land was production of crops, timber, and pasture (41, 22, and 31 percent, respectively). The most frequent reasons for purchase were reported to be expansion of land holdings, investment and residential (38, 27, and 15 percent, respectively). In addition to reason for purchase, respondents also indicated that residential, recreational, the presence of a highway, and flooding were the most frequent factors affecting rural real estate values in Louisiana (29, 22, 14, and 14 percent, from respectively).

Summary of Hedonic Error Model Results

Hedonic model analyses were conducted using ordinary least squares (OLS) and maximum likelihood (ML) spatial techniques. Initially, an OLS diagnostic model was carried out in order to verify that the assumptions with respect to the behavior of residuals held. Statistical tests indicated that assumptions of normality and homoskedasticity of errors held for data from all eight submarket areas. Multicollinearity condition numbers indicated that there were no problems related to correlation between observations. However, Lagrange Multiplier (LM) tests indicated the presence of spatial autocorrelation. In addition to determining the presence of spatial autocorrelation, LM results indicated that the spatial error model (as opposed to the spatial lag model) was the appropriate spatial specification for all eight submarket areas. Other measures of fit, such as log likelihood numbers and likelihood ratio tests, confirmed the presence of spatial autocorrelation.

Due to the presence of spatial autocorrelation in the data, it is not possible to make accurate statistical inferences based on OLS estimates. Therefore, hedonic price models were estimated by maximum likelihood (ML) spatial error procedures. The nearest neighbors weight matrix was used in the estimation of spatial error models.

Table 6.1 summarizes the results of the hedonic maximum likelihood error model for the eight Louisiana rural land submarkets described in Chapter 5. These results indicate the impact these land attributes have on per acre land value. The estimates presented are all statistically significant and have the expected signs.

Estimates of models presented in Table 6.1 indicate consistency of relationships across rural land submarkets for some model variables, while other variables were less consistent in influencing land values across the same submarkets. The effect of natural log of size (LNSIZE) was estimated to have a negative influence on rural land values in six of the eight rural land submarkets areas. For the Southwest area, the effect of size is reflected when the tract of land is located in Calcasieu Parish. The negative influence was expected because a relatively larger number of potential buyers compete for small tracts as opposed to relatively fewer buyers that compete for larger sized tracts.

Table 6.1. Spatial error maximum likelihood hedonic model estimates for rural land submarket models, Louisiana Rural Land Survey, 1993-2002.

VARIABLE	WESTERN	RED RIVER	NORTH CENTRAL	NORTH DELTA	SOUTHWEST	CENTRAL DELTA	SOUTHEAST	SUGARCANE
LNSIZE	-0.256984	-0.235212	-0.193886			-0.090165	-0.284385	-0.303739
CROP		0.002735						
PASTURE			0.004827					
TIMBER		-0.001544	0.001991		-0.003723			
CB				0.186248		0.159848		
TIME	0.003953	0.007066	0.007565	0.004561	0.003550	0.005214	0.007070	0.002933
ORLEANS							0.449958	
CALCASIEU					1.426367			
CALSIZE					-0.346701			
CALTIME					0.005774			
VALUE	0.00000085	0.0000109	0.0000098	0.0000012			0.0000019	
PR	0.259173	0.261855	0.178376			0.215496		0.110264
DNT	-0.012808							
TNT					-0.403209			
INVTC		0.169551	0.3117378	0.131945		0.203447		0.121391
INVTT							0.008779	
S5	0.230569	0.122398						
S6			-0.123761					
S19								0.143523
RPRECR				-0.149122		-0.261022	-0.261594	-0.562251
RPRES		0.207284		0.192568				
RPF		-0.243820						
RPCOM							0.619291	
RPINV								0.279344
RESINF	0.342537					0.335312		
COMINF					0.949047			
FLINF			-0.319355			-0.302358		
HWYINF		0.403059						
INTERCEPT	7.597091	6.823595	6.420684	6.140055	7.072829	6.542110	8.326706	8.232008
ALPHA	0.335000	0.483000	0.330000	0.695000	0.988000	0.623000	0.943000	0.902000

The month of sale (TIME) estimate was found to be positive and statistically significant in all eight submarket areas. The positive coefficient was expected because of the effects of an upper trend in values and inflation during the survey period. The estimated value of improvements (VALUE) was found to have a positive influence on rural land values in five of the eight rural land submarkets. The positive sign was expected because addition of houses, dwellings, fences, and irrigation canals, is expected to increase the value of a tract of land.

Similarly, the inverse of travel time to the nearest city (INVTC) was estimated to have a positive influence on the price of rural land in six of the eight rural land submarket areas. A negative sign for travel time to the nearest city reflects higher transportation costs for tracts located further from principal markets. The positive sign reflects the reciprocal of the negative relationship.

Paved road access (PR) was estimated to have a positive influence on rural land values in five of the eight rural land submarket areas. The positive coefficient was expected because a paved road represents ease of access and enhances development potential. Reason for purchase recreational (RPREC) had a negative influence on rural land values in four of the eight rural land submarket areas. The negative sign was expected because recreational land is usually bought for hunting and it has no value for other uses that could generate more rent.

Results of other variables used to measure land attributes indicated a wide variation in factors influencing land values in submarkets. For example, the percentage of cropland (CROP) was estimated to be statistically significant only in the Red River area and the percentage of pasture (PASTURE) was estimated to be statistically significant only in the

North Central Area. In general, these results reflect the differences in rural land submarkets and the wide array of factors prevailing in the statewide rural land market.

Summary of Estimated Marginal Implicit Prices

Implicit prices were estimated to measure the amount by which the per acre land price changes given a one unit change in land characteristics. A summary of marginal implicit prices, for all submarkets, estimated from the maximum likelihood spatial error models, is presented in Table 6.2.

Marginal implicit prices for travel time to nearest city (INVTC) were estimated to range from –$58 per acre in the Red River Area to -$888 per acre in the Southeast Area. This means that, in the Southeast Area, an hour increase in travel time to the nearest city decreases value by $888 per acre, while in the Red River Area an hour increase in travel time decreases value by $58 per acre. For the Southwest Area, marginal implicit price for travel time to nearest town (TNT) indicates that a one-hour increase in travel time to the nearest town decreases land value by $691 per acre.

Marginal implicit prices estimated for road type access and economic development variables varied across the submarket areas. The marginal implicit price for paved road access (PR) was estimated to range from $154 per acre in the North Central Area to $345 in the Western Area. The marginal implicit price for the Western Area suggests that a tract with paved road access could sell for $345 more per acre than a tract that does not have paved road access.

Economic development measures, including reasons for purchase, purchase influences, and location of a tract in a metropolitan statistical area, were shown to have a strong positive effect on per acre rural land values. The marginal implicit price for reason for purchase residential (RPRES) was estimated to be $153 per acre in the North Delta Area and

Table 6.2. Marginal implicit prices from hedonic OLS and spatial error model estimates evaluated at the mean price and characteristic levels, Louisiana Rural Land Survey, 1993-2002.

VARIABLE	WESTERN	RED RIVER	NORTH CENTRAL	NORTH DELTA	SOUTHWEST	CENTRAL DELTA	SOUTHEAST	SUGARCANE
LNSIZE	-4.87	-1.25	-1.78			-0.22	-6.99	-2.74
CROP		2.63						
PASTURE			3.85					
TIMBER		-1.48	1.59		-6.38			
CB				152.09		146.83		
TIME	4.29	6.78	6.03	3.40	6.08	4.49	20.87	5.84
ORLEANS							1,637.82	
CALCASIEU					5,109.09			
CALSIZE					-593.97			
CALTIME					9.89			
VALUE	8.78	104.38	78.43	9.27			56.22	
PR	345.30	285.62	153.86			206.33		
DNT	-13.76							
TNT					-690.78			
INVTC		-58.51		-117.83		-160.95	-888.14	-78.70
INVTT			-269.66					
S5	271.59	122.77						
S6			-94.56					
S19								306.20
RPREC				-105.27		-200.94	-588.48	-946.92
RPRES		217.38		153.27				
RPF		-212.10						
RPCOM							2,419.89	
RPINV								730.90
RESINF	425.78					335.11		
COMINF					2,617.61			
FLINF			-221.90			-228.03		
HWYINF		463.71						

\$217 per acre in the Red River Area. If the reason for purchase were investment (RPINV), the tract would be valued \$731 more per acre in the Sugarcane Area. Similarly, a tract bought for commercial purposes (RPCOM) was estimated to be valued at \$2,420 more per acre in the Southeast Area. The marginal implicit price for residential influence (RESINF) indicated that a tract with potential for residential development would be valued at \$335 more per acre in the Central Delta Area, and \$426 more in the Western Area. The marginal implicit price for highway influence (HWYINF) suggests that the potential in land use brought by highway construction would increase land value by \$464 per acre in the Western Area. Likewise, the marginal implicit price for commercial influence (COMINF) indicates that land associated with potential commercial use would be sold at \$2,618 per acre more in the Southwest Area. Finally, a tract of land located in the New Orleans MSA (ORLEANS) was estimated to be valued at \$1,638 more per acre than a tract in the Southeast Area not located in this MSA.

In Chapter 5, results of marginal implicit prices obtained via OLS and ML estimation procedures were compared. Results indicated that when percent changes in MIPs obtained by OLS and ML were above ten percent, some consistencies were observed across rural land submarkets. For example, MIP values for timberland (TIMBER) were consistently overestimated at the mean value when using OLS estimates. Similarly, MIP for value of improvements (VALUE) and reason for purchase residential (RPRES) were consistently overestimated at the mean value when using OLS estimates. MIP values for travel time variables (INVTC, INVTT, and TNT) were consistently underestimated at their means when using OLS estimates.

Conclusions

Results of the Louisiana Rural Land Market Survey indicate that a substantial variation in rural land prices exists across the state. Variation in prices could be explained by type of commodity produced, location advantages with respect to centers of commercialization, other significant influences, and tract physical characteristics.

The incorporation of the spatial component helped to improve model estimation. In all instances, the presence of spatial autocorrelation was an indication that erroneous inferences could have been made from ordinary least squares estimates. Differences in coefficient estimates as well as in the signed root deviances could be observed from the results.

The evidence of differences in the estimation procedures was more evident when marginal implicit prices of rural land characteristics were calculated. In many instances, marginal implicit prices at the mean obtained from OLS estimates were overestimated or underestimated when compared to MIP values obtained from using ML estimates.

Cotton base acreage was found to be statistically significant in the North Central and the Central Delta areas where this commodity is produced. Since cotton base is a government program, changes in price support policies for cotton could have a large impact in the value of land with cotton base acreage.

Results from this study indicate a structural difference in the Southwest rural land market of Louisiana in that rural land market activity in Calcasieu Parish is different than the rest of the Southwest Area. For example, results of the marginal implicit prices for the size of tract and time of sale suggested that these variables have a greater effect on rural land located in the Calcasieu Parish than tracts of land located in the remaining Southwest Area. These findings are expected to help rural appraisers make a more accurate appraisal in the

Southwest market. It is expected to find higher land values in the Calcasieu area than in the remainder of the Southwest Area because of the metropolitan influence of Lake Charles.

Limitations and Further Research

A potential limitation of this study was the number of observations for some submarket areas. Future research should include continued emphasis on collecting new rural land sales to add to the data base.

Several respondents for this research reported sales electronically. Emphasis should be on developing and conducting an electronic survey. In this matter, respondents could input data on a regular basis.

Rural land submarket areas used in this study were developed in a previous study. Future research should review these submarket areas and look at new procedures (including GIS techniques) for identifying and estimating rural land submarkets.

This study used the nearest neighbor method for estimating spatial weight matrices. Future research should explore other methodologies in estimating spatial weight matrices.

This study described how spatial error model techniques can be used to improve the accuracy of rural land market estimates. Future research should test other spatial econometric procedures such as the mixed spatial models.

Caution should be used when applying estimates from this study. Estimates from this study are intended to contribute to additional sources of information in the appraisal process and should not be used as the sole source of valuation. Current local market conditions may not be accurately reflected in the results reported here because of limited data in some cases and the complexity of factors influencing values in the local market.

Given the importance of the travel time variables, estimation procedures should be refined. For example, travel delays should be considered in the estimation of travel time to nearest cities and towns. In addition, towns used in the estimation of distance and travel time variables should be selected by using GIS procedures.

Findings of this study suggest that land values are heavily influenced by the relative location to metropolitan areas. In general, future research should include identifying new and improved measures for explaining per acre rural land values.

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APPENDIX A. SOIL CLASSIFICATION AND TOWNS AND CITIES USED IN THIS STUDY

Table A.1. Key used for identification of soil types in Louisiana.

Soil	Definition
1	Western Tertiary Uplands - Uplands
2	Eastern Gulf Coast Flatwoods - Floodplains
3	Eastern Pleistocene Terraces - Terraces
4	Ouachita River Valley Alluvium – Natural Levees
5	Western Pleistocene Terraces - Terraces
6	Western Pleistocene Terraces - Floodplains
7	Eastern Gulf Coast Flatwoods - Terraces
8	Western Tertiary Uplands - Floodplains
9	Western Gulf Coast Flatwoods - Terraces
10	Subtropical Mississippi Valley Silty Uplands - Floodplains
11	Southern Mississippi Valley Silty Uplands - Uplands
12	Southern Mississippi Valley Silty Uplands - Floodplains
13	Subtropical Mississippi Valley Silty Uplands - Uplands
14	Western Gulf Coast Flatwoods - Floodplains
15	Gulf Coast Prairies - Terraces
16	Eastern Pleistocene Terraces - Floodplains
17	Southern Mississippi Valley Alluvium - Natural Levees
18	Southern Mississippi Valley Alluvium - Backswamps
19	Subtropical Mississippi Valley Alluvium - Natural Levees
20	Subtropical Mississippi Valley Alluvium - Backswamps
21	Red River Valley Alluvium - Natural Levees
22	Red River Valley Alluvium - Backswamps
23	Gulf Coast Prairies Depressions and Floodplains
24	Gulf Coast Deltaic Marsh - Brackish
25	Gulf Coast Chenier Marsh - Fresh
26	Gulf Coast Chenier Marsh - Brackish
27	Gulf Coast Chenier Marsh - Saline
28	Gulf Coast Deltaic Marsh - Fresh
29	Ouachita River Valley Alluvium - Backswamps
30	Gulf Coast Deltaic Marsh Saline
31	Water

Table A.2. Parish seats and cities used in the estimation of distance and travel time estimates.

Submarket Area	Classification	Parish name	Latitude	Longitude
A: Western Area				
De Ridder	Town	Beauregard	30.84585	-93.29114
Leesville	Town	Vernon	31.13757	-93.27501
Mansfield	Town	De Soto	32.03397	-93.70255
Many	Town	Sabine	31.56553	-93.47504
B: Red River Area		Town		
Natchitoches	Town	Natchitoches	31.75564	-93.09783
Alexandria	Town	Rapides	31.29213	-92.46344
Bossier City	Town	Bossier	32.52257	-93.70279
Colfax	Town	Grant	31.51904	-92.70585
Shreveport	Town	Caddo	32.47584	-93.77451
Coushatta	Town	Red River	32.02498	-93.34069
C: North Central Area				
Arcadia	Town	Bienville	32.55112	-92.92471
Farmerville	Town	Union	32.77404	-92.40060
Homer	Town	Claiborne	32.78920	-93.05794
Jena	Town	La Salle	31.68419	-92.13131
Jonesboro	Town	Jackson	32.23695	-92.71013
Minden	Town	Webster	32.61345	-93.28579
Ruston	Town	Lincoln	32.53195	-92.63978
Winnfield	Town	Winn	31.92226	-92.64139
D: North Delta Area				
Bastrop	Town	Morehouse	32.77777	-91.91220
Columbia	Town	Caldwell	32.10161	-92.07736
Lake Providence	Town	East Carroll	32.80534	-91.17211
Monroe	Town	Ouachita	32.51180	-92.08506
Oak Grove	Town	West Carroll	32.86230	-91.39131
Rayville	Town	Richland	32.47172	-91.75737
St. Joseph	Town	Tensas	31.92029	-91.23943
Tallulah	Town	Madison	32.40817	-91.18771
Winnsboro	Town	Franklin	32.16023	-91.72059
E: Southwest Area				
Abbeville	Town	Vermilion	29.97441	-92.12373
Cameron	Town	Cameron	29.79913	-93.32504

(table continued)

Submarket Area	Classification	Parish name	Latitude	Longitude
Crowley	Town	Acadia	30.21280	-92.37251
Jennings	Town	Jefferson Davis	30.22312	-92.65849
Lafayette	Town	Lafayette	30.21545	-92.02962
Oberlin	Town	Allen	30.61847	-92.76440
Lake Charles	Town	Calcasieu	30.22997	-93.21836
Ville Platte	Town	Evangeline	30.68946	-92.27771
F: Central Delta Area				
Jonesville	Town	Catahoula	31.62641	-91.81862
Marksville	Town	Avoyelles	31.12694	-92.06319
New Roads	Town	Pointe Coupee	30.69432	-91.45425
Opelousas	Town	St. Landry	30.52489	-92.08363
Vidalia	Town	Concordia	31.56849	-91.44058
G: Southeast Area				
Baton Rouge	Town	East Baton Rouge	30.44916	-91.12615
Bogalusa	Town	Washington	30.78756	-89.86028
Clinton	Town	East Feliciana	30.86125	-91.01513
Denham Springs	Town	Livingston	30.47989	-90.95940
Greensburg	Town	St. Helena	30.82973	-90.67014
Hammond	Town	Tangipahoa	30.50784	-90.46021
St. Francisville	Town	West Feliciana	30.78379	-91.37923
Slidell	Town	St. Tammany	30.28123	-89.77773
H: Sugarcane Area				
Laplace	Town	St. John the Baptist	30.07255	-90.47286
Donaldsonville	Town	Ascension	30.09825	-90.99678
Houma	Town	Terrebonne	29.59751	-90.71784
Lutcher	Town	St. James	30.04260	-90.69886
Morgan City	Town	St. Mary	29.70202	-91.20438
Napoleonville	Town	Assumption	29.93778	-91.02675
New Iberia	Town	Iberia	30.00466	-91.82210
Plaquemine	Town	Iberville	30.28339	-91.24065
Port Allen	Town	West Baton Rouge	30.45094	-91.20888
St. Martinville	Town	St. Martin	30.12516	-91.83064
Thibodaux	Town	Lafourche	29.79020	-90.82095
CITY				
Alexandria	City	Rapides	31.29213	-92.46344
Baton Rouge	City	East Baton Rouge	30.44916	-91.12615

(table continued)

Submarket Area	Classification	Parish name	Latitude	Longitude
CITY				
Houma	City	Terrebonne	29.59751	-90.71784
Lafayette	City	Lafayette	30.21545	-92.02962
Lake Charles	City	Calcasieu	30.22997	-93.21836
Monroe	City	Ouachita	32.51180	-92.08506
New Orleans	City	Orleans	30.06605	-89.93143
Shreveport	City	Caddo	32.47584	-93.77451

APPENDIX B. DATA COLLECTION PROCEDURES

LOUISIANA RURAL LAND MARKET SURVEY

SECTION I. ACTUAL SALES OF RURAL REAL ESTATE

Instructions

- Survey Period: July 1, 1998 to June 30, 2002 (4 YEARS).
- All information is considered strictly confidential.
- Please provide as much information as posssible on as many actual sales of rural real estate as you have knowledge within the survey period, even if you cannot answer all questions.
- Only include sales of ten (10) acres or more, outside the limits of major metropolitan areas (Shreveport, Monroe, New Orleans, Baton Rouge, Lafayette, Lakes Charles, Alexandria). Please do not include sales involving close relatives (father to son, etc.).
- This survey goes out to column AZ, and you may include as many rows as you wish.
- Return completed survey in enclosed postage-paid envelope or email it to Lonnie Vandeveer. at lvandeveer@agctr.lsu.edu
- If you would like a copy of the results of this survey, please write your name and address on the back of the return envelope (not on the survey itself), or email to Lonnie Vandeveer.
- Please indicate your affiliation:

______	Appraiser	______	Production Credit Association
______	Commercial Bank	______	Realtor
______	Farm Service Agency	______	Other (please specify)
______	Federal Land Bank	____________	

Sale No.	Date of Sale	Location of Land: Parish	Twnshp/Range	Section	Quadrant*	Number of Acres	Price per Acre	Approximate Value of Improvements ($): House	Barns, Fences, etc.
example		St. Landry	3S/3E	12	SW 1/4	300	$975	$30,000	$9,500
1									
2									
3									
4									
5									
6									
7									

LOUISIANA RURAL LAND MARKET SURVEY-CONTINUED

Type of Tract Access Road and Approx. Paved Road Frontage (feet) a. paved b. gravel c. dirt	Highest & Best Use a. crops b. pasture c. timber d. residential e.transitional f.recreational g. industrial/ commercial h.aquaculture i. other (please specify)	Percent of Land in				Commodities a.cotton b.soybeans c.sugarcane d.corn e.grain sorghum f.rice g.vegetables h.beef i.dairy j.poultry k.catfish l.crawfish m1.cutover pine m2.premerchantable pine timber m3.merchantable pine timber Primary		Produced: n1.cutover hardwood n2.premerchantable hardwood timber n3.merchantable hardwood timber o.other (specify) p.none q.wheat r.peach trees s.pecan trees Secondary		Acres	
		Crops	Pasture	Timber	Other	Commodity	Acres	Commodity	Acres	Rice	Cotton
a (2500)	a	90%	5%	0%	5%	b	240	o. oats	30	0	0

LOUISIANA RURAL LAND MARKET SURVEY-CONTINUED

of Crop Base			Approximate General Soil Composition Percentages a. sand b. clay c. mixed	Approx. Total Value of Improve-ments to the Land a. timber b. seedlings c. growing crops d. improved pasture e. other (please specify) f. irrig. equip. ($)	Any Significant Influence(s) On Land Value: a. commercial b. residential c. pond(s) d. rural water system e. flooding f. recreational g. urban fringe h. highway i. other (please specify) j.none k.environmental problems l. land leveling m. drainage improvement	Number Acres Irrigated	Percent of Mineral Rights Purchased (if any) (%)	Govt. Programs Enrolled a. CRP b. WRP c. other (please specify) (acres)	Principle Reason For Purchase: (if known) a. expansion b. residence c. recreation d. investment e. commercial development f. establish farm g. other (please specify)
Corn	Wheat	Other							
0	30	0	b30% c70%	c($8400)	c(1)	80	50%	a(20)	a

LOUISIANA RURAL LAND MARKET SURVEY-CONTINUED

SECTION II. ESTIMATIONS ON CROP SHARE/LAND RENTAL MARKETS

Please approximate typical crop share/land rental arrangements in your area.

______________________________ **I do not have knowledge of typical rental arrangements.**

CROP OR ACTIVITY		CASH RENT (per acre)	SHARE RENT (per acre share arrangement)
example: corn	X	$40	landowner shares 1/5 crop, pays 1/4 fertilizer
cotton			
soybeans			
corn			
wheat			
rice			
sugarcane			
other crop			
(please specify)			
pasture			
hunting/recreation			

SECTION III. LOUISIANA RURAL LAND MARKET ESTIMATES

1. For the following types of rural land that are typical and which you are familiar with in your area, please estimate the range and average per acre values as June 30, 2002

	Low	High	Average
Dry cropland	________ /acre	________ /acre	________ /acre
Irrigated Cropland	________ /acre	________ /acre	________ /acre
Pastureland	________ /acre	________ /acre	________ /acre
Timberland	________ /acre	________ /acre	________ /acre

2. Relative to the last year, do you expect the average market value of rural land in your area in the next year to: increase by ________ percent or decrease by ________ or remain the same ________ (check)?

3. Are you aware of any specific factor(s) likely to influence average rural land values over the next 12 months?

If yes, please specify: ________________________________

November 29, 2002

Reliable rural land market information is vital to landowners, investors, borrowers, lenders, appraisers, and the general public. Recognizing the need for rural land market information, we are continuing our efforts in developing a rural real estate data base, using the **Louisiana Rural Land Market Survey**.

To facilitate the continued development of the rural real estate data base, we are asking individuals who have knowledge of the Louisiana rural land market to fill out and return the enclosed survey as soon as possible. A copy of the annual survey report will be sent to all participants who write their name and address on the back of the enclosed postage paid return envelope (not on the survey itself). The results of the survey will be mailed to you in the spring of 2003. The enclosed survey form has an identification number for mailing purposes only. You may be assured of complete confidentiality, as your name will never be connected with your responses in any manner. No information on individual sales will be released to the public.

Section I of the survey requests information on actual sales of rural real estate for the 4 year period of July 1, 1998 to June 30, 2002. Please enter as much information as possible per sale, even if you cannot answer all questions. We are requesting detailed location information (township, range, section) to examine the effect of distance and location variables (e.g. miles to the parish seat, nearest city) on land values.

Section II asks for you to approximate crop share or land rental market information for your area, if you have knowledge of typical arrangements. Section III requests current land market information and your expectations of the rural Louisiana land market over the next twelve months. You may use Section IV for any additional comments that you would like to make concerning the Louisiana rural land market or the survey itself. You may also use Section IV to provide us with names and addresses of other individuals or groups (appraisers, realtors, etc.) who would be knowledgeable of rural land values and should be included in our survey.

If you prefer to submit data electronically, please go to www.agecon.lsu.edu and click on Rural Land Survey. Complete the survey and email a saved copy to lvandeveer@agctr.lsu.edu. Alternately, you may mail a printed copy to Lonnie Vandeveer at the address printed below. Please include the identification number on the back of the enclosed survey on the electronic submission.

Should you need an additional survey form, or if you have any questions or comments, please feel free to contact us. If you do not have knowledge of the Louisiana rural land market, please check the box below and return this letter in the return envelope. Thank you for your help.

Sincerely,

Steven A. Henning
Associate Professor
(tel: 225-578-2718)
(E-mail: shenning@agctr.lsu.edu)

Lonnie R. Vandeveer
Professor
101 Ag. Adm. Bldg.
Baton Rouge, LA 70803-5604
(tel: 225-578-2754)
(E-mail: lvandeveer@agctr.lsu.edu)

☐ Please check here and return this letter in the enclosed return envelope if you do not have knowledge of the Louisiana rural land market.

January 2, 2003

A few weeks ago a questionnaire seeking information about the Louisiana rural land market was mailed to you. According to our records, we have not yet received your response. If you have responded, thank you. In the event that your questionnaire has been misplaced, a replacement is enclosed.

We have undertaken this research project in recognition of a need for the development of a data base that will allow the analysis of land values and factors influencing the rural Louisiana land market. For the results of this research to be truly representative of the entire state, sales data from all areas of the state are needed. Therefore, we are asking that you complete the questionnaire and return it as soon as possible.

If you prefer to submit data electronically, please go to www.agecon.lsu.edu and click on Rural Land Survey. Complete the survey and email a saved copy to lvandeveer@agctr.lsu.edu. Alternately, you may mail a printed copy to Lonnie Vandeveer at the address printed below. Please include the identification number on the back of the enclosed survey on the electronic submission.

If you cannot complete the questionnaire due to a lack of involvement in the Louisiana rural land market, please check the box below and return this letter in the return envelope. Please disregard this reminder if you have responded to our original mailing.

Your contribution to the success of this research is greatly appreciated.

Sincerely,

Steven A. Henning
Associate Professor
(tel: 225-578-2718)
(E-mail: shenning@agctr.lsu.edu)

Lonnie R. Vandeveer
Professor
101 Ag. Adm. Bldg.
Baton Rouge, LA 70803-5604
(tel: 225-578-2754)
(E-mail: lvandeveer@agctr.lsu.edu

☐ Please check here and return this letter in the enclosed return envelope if you are not involved in the Louisiana rural land market.

P.S. A copy of our annual report, based on the results of this survey, will be sent to all participants who write their name and address on the back of the enclosed return envelope.

Dear Madam or Sir:

Recently a questionnaire seeking information about the Louisiana rural land market was mailed to you. This card is a reminder to please fill out the questionnaire. If you have already completed and returned it to us, please accept our thanks. If not, please do so today. It is extremely important that your questionnaire be completed and returned by you, so that the results of this study will be truly representative. If by some chance you did not receive the questionnaire, or it has been misplaced, please call or e-mail us and another will be sent to you immediately.

Sincerely,

Steven A. Henning	**Lonnie R. Vandeveer**
Associate Professor	**Professor**
(225) 578-2718	**(225) 578-2754**
shenning@agctr.lsu.edu	**lvandeveer@agctr.lsu.edu**

Figure B.1. Post card remainder sent fourteen days after the initial survey mailing, 2002 Louisiana Rural Land Market Survey.

Dear Madam or Sir:

A questionnaire on the Louisiana rural land market was recently mailed to you.

- **If you have already completed and returned it to us, please accept our thanks and disregard this reminder.**
- **If you have not completed the questionnaire, please do so today. Your participation will help us develop better land market research information.**
- **If you did not receive the questionnaire, or it has been misplaced, please call or e-mail us for another copy. Or complete the Louisiana Rural Land Market Survey online at: http://www.agecon.lsu.edu.**

Sincerely,

Steven A. Henning	**Lonnie R. Vandeveer**
Associate Professor	**Professor**
(225) 578-2718	**(225) 578-2754**
shenning@agctr.lsu.edu	**lvandeveer@agctr.lsu.edu**

Figure B.2. Post card remainder sent ten days after the second mailing, 2002 Louisiana Rural Land Market Survey.

VITA

Patricia Soto is a native of San José, Costa Rica. She received a degree in agronomy from the University of Costa Rica in August 1989. As a cofounder of Arbofilia, an NGO, her main activities were to write proposals and develop sustainability programs with women in rural areas. In September 1989, Patricia was granted a scholarship (USAID/San José Office) to complete a master's degree in the United States, and in 1990 she enrolled at Auburn University in the Department of Fisheries and Allied Aquacultures. Patricia returned to Costa Rica in 1992 with a Master of Science degree in fisheries and allied aquacultures and worked for Arbofilia. She resigned in 1994 and came to Louisiana State University to pursue a master's degree in agricultural economics. She returned to Costa Rica that August to teach for a university and high school. In January 1997, Patricia returned to the Department of Agricultural Economics and Agribusiness at Louisiana State University where she earned a Master of Science degree in agricultural economics in May 1999. After completing her master's, she continued in the doctoral program in the same department. Patricia gave birth to her daughter, Nicole Marie, in March 2002.